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# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

## VOLUME 37

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

29 West Thirty-ninth Street, New York

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## THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37, January—December, 1915

### PROCEEDINGS AND SOCIETY AFFAIRS



NOTE: A discussor is distinguished from the author of a paper by (D) placed after the name of the paper.

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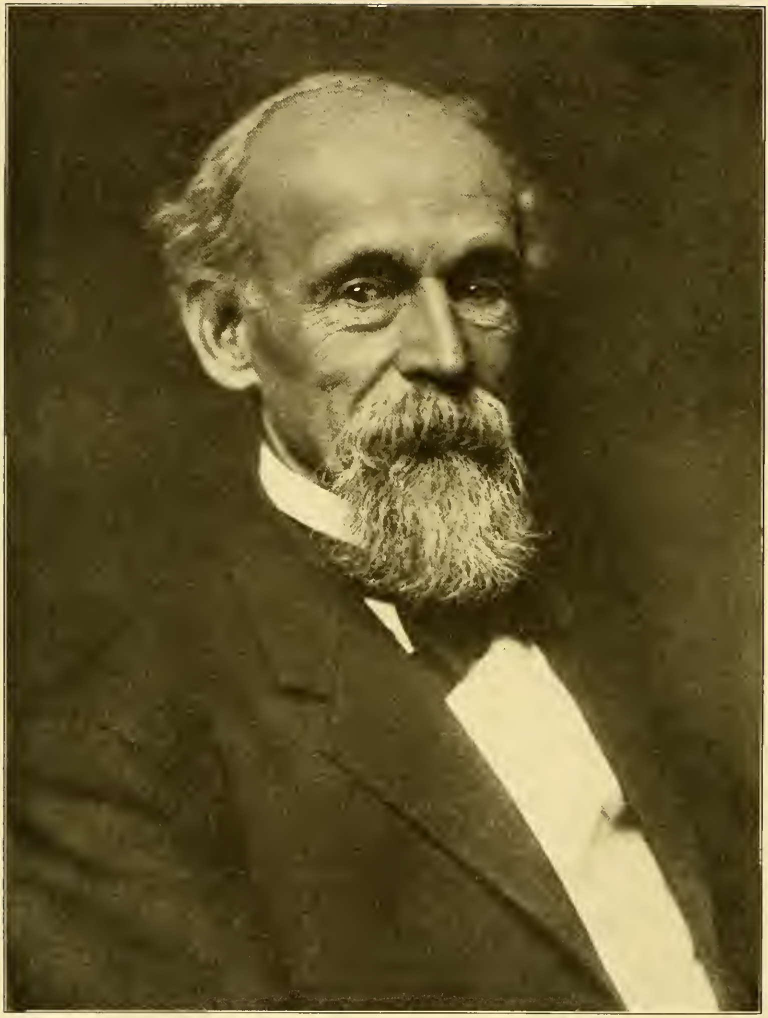
## ENGINEERING SURVEY



Note: In the transliteration of Russian words strictly phonetic notation is used; Russian *y* is denoted by *oo*, Russian *x* by *kh*



JOHN A. BRASHEAR
PRESIDENT 1915
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 JANUARY 1915 Number 1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## COMING MEETINGS OF THE SOCIETY

*January* 6, *Boston, Mass.*, Engineers Club. Topic: Aviation, with addresses by G. S. Curtis, A. A. Merrill, and others.

*January* 7, *Buffalo, N. Y.* Subject: Recent Development in Steam Turbine Engineering, Prof. J. A. Moyer of Pennsylvania State College.

*January* 8, *Chicago, Ill.* Railroad meeting, with papers on Locomotive Superheaters and Stokers.

*January* 14, *Philadelphia, Pa.* Joint meeting with the Franklin Institute. Paper: Modern Steels and their Heat Treatment, by Robert R. Abbott.

*January* 28, *Buffalo, N. Y.* Subject: Manufacture of Portland Cement, by Prof. R. C. Carpenter of Cornell University.

*January, New York City.* Subject and date to be announced.

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 January 1915 Number 1


## JOHN A. BRASHEAR

President of the Society for 1915

John A. Brashear was born in Brownsville, Pa., November 24, 1840. His father was a saddler, his mother the daughter of Nathaniel Smith, from whom young Brashear inherited his taste for science and mechanics, the grandfather having constructed one of the first telegraphic instruments made in Western Pennsylvania, and also succeeded in taking some of the earliest daguerreotypes.

The grandfather had a great love for astronomy and taught the constellations to his grandson when he was only eight years of age. About this time he had an opportunity to see the moon and Saturn through a small telescope made by a watchmaker of McKeesport, Pa., which had been brought to Brownsville, a small charge being made for the view. This left an indelible impression on the mind of young Brashear, and even at this early age he had a desire to own a telescope some day, perhaps, in the far distant future.

His education was confined to the common schools of Brownsville, but he found in his last two teachers men of large brains and a love for their calling, which made the little red brick school-house to him a real college and his only alma mater.

At 17 he was apprenticed to the patternmaking and engine-building trade at the works of John Snowden & Sons, and after finishing his trade, went to Louisville, Ky., where he engaged in engine-building with the firm of Dennis Long & Company.

While he was in Louisville the Civil War broke out and he came to Pittsburgh, where he took charge of the machinery of the Zug & Painter mill in 1862. In 1867 he was asked to take charge of the machinery in McKnight, Duncan & Company's mill, which he entirely rebuilt after a destructive fire. During his stay at this mill, Dr. George Barker of the University of Pennsylvania came to Pittsburgh to give a course of lectures on the spectrum analysis, a science then in its childhood, which Mr. Brashear heard, and as a result of which became so deeply interested in the subject that it was not long until he constructed a bisulphide of carbon prism and began the study himself.

After seven years with McKnight, Duncan & Company, his old friend Christopher Zug asked him to come to his mill again. The offer was accepted and he remained with the firm of Zug & Company until 1881, when he yielded to his great desire to construct astronomical instruments for amateurs, particularly in the line of silvered glass reflecting telescopes, which had not yet been made in this country except by Dr. Henry Draper, and decided to leave the rolling mill for good.

In 1862 Brashear married Phœbe Stewart, who was his faithful and devoted helpmate in all his early and later work, and the husband and wife spent three years making their first lens and constructing a 5-in. refractor. When this did not prove very satisfactory, they undertook a 12-in. reflecting telescope, the glass of which was broken by accident after two years of night labor, for all this work was done during Mr. Brashear's stay in the rolling mill.

Nothing daunted, the good wife had everything made ready in the little workshop the day after the accident, and in two months a new 12-in. telescope was ready for observation, and was used for many years in a study of celestial phenomena, including the question of changes on the moon's surface, comets and nebulæ, for which the 12-in. telescope was particularly well suited.

Professor Langley early became interested in Mr. Brashear's work and entrusted him with a number of important pieces of apparatus, among them his accurate mirrors, solar storage energy apparatus, etc. At the time Professor Langley was making his study of the selective absorption of the earth's atmosphere and its relation to organic life upon the earth, he required accurate rock salt lenses and prisms, which had not been made with the precision demanded until the problem was solved by Mr. Brashear. The method was given to the scientific world in a paper read before the American Association of Science about 1885. Langley's memorable researches in this great field made him famous, and he never failed to give Mr. Brashear a fair share of the credit of making his discoveries possible.

Mr. William Thaw, the Pittsburgh philanthropist and a friend of Langley's, sent for Brashear, and insisted upon building him a better workshop, finally in-

ducing him to move to Allegheny, so as to be near the observatory. Here began a lasting friendship with Mr. Thaw and Professor Langley. For three years all the early experimental equipment for Langley's researches in aviation, ærodynamics and ærodromics was made in the Brashear laboratory.

Orders began to come in to the new workshop, especially in the line of spectroscopes, and about this time Professor Rowland of Johns Hopkins University, entrusted Mr. Brashear with the making of the delicate plates on which he was to rule his wonderful diffraction gratings.

About this time Mr. Brashear's daughter married Mr. McDowell, who at once joined in the work, soon proving himself to be a master in the production of accurate optical surfaces. Brashear has always given the largest share of credit to Mr. McDowell, his associate, who has succeeded in reaching the highest demands of modern research, in optical lines.

Dr. Charles Hastings of Yale University early became associated with the firm, and with his mastery of mathematical optics, computed the curves of many object glasses of the highest type, doing away with all empiricism. The last large objective computed by him, and only recently finished by Mr. McDowell, is the 30-in. glass for the Allegheny Observatory, which is said to be the most perfect glass in the world today. The mountings of many of the larger telescopes were constructed by Messrs. Warner and Swasey, Past-Presidents of the Society.

Spectroscopes of every description for research have been made in Mr. Brashear's shop for institutions all over the world, for both astronomical and physical research, spectroheliographs, for studies of the sun; indeed, such has been the progress of astronomical spectroscopy since the Brashear works turned out the first spectroscope for Professor Keeler, for use with the great telescope of the Lick observatory, that it seems a new science, and remarkable discoveries in celestial physics are coming to us every day. Putting the matter grossly, the Keeler spectroscope was thought to be over heavy, as it weighed 45 lb. The Porter spectroscope, made for the Allegheny Observatory, weighs nearly nine tons, with its counterpoises, etc.

The development of the astronomical photographic camera has been carried along as one of the principal features of the Brashear works. The double camera of the 40 centimeter photographic telescope of the Heidelberg Observatory is one of the products of the firm and is the handiwork of Mr. McDowell, whose skill and judgment were equal to any optical task, but who was unwilling to pass any work of precision without the final criticism of Mr. Brashear.

The delicate plane parallel mirrors made for the study of the International Standard Meter in terms of light waves, were made by Mr. McDowell, and were used with the Interferometer devised by Dr. Michelson, for whom the surfaces were made. The Standard Meter has now an absolute value in something that can never be destroyed. The limiting error of these delicate surfaces was less than $^1/_{200,000}$ in., such is the precision demanded in modern scientific research.

Mr. Brashear early became interested in educational work, beginning among his fellow workmen in the rolling mill. He has given over five hundred lectures to working men's organizations, indeed, to all classes of citizens interested in the beauties of science. He has personally known most of the eminent men in science of the last forty years, has served as acting chancellor of the University of Pittsburgh, as acting director of the Allegheny Observatory, and has been a member of the Board of Trustees of the Carnegie Institute since its beginning, and also of the Carnegie Technical Schools, the University of Pittsburgh, and is chairman of the Observatory Committee, as well as of several other institutions of an educational character.

Five years ago he was entrusted with a fund of $250,000 by a friend of education, for the betterment of teaching and teachers in the public schools of Pittsburgh. Forming a commission to assist him in carrying out the donor's wishes, 605 teachers have been sent to summer schools from Maine to California for study, rest and recreation, and the results have been invaluable.

Mr. Brashear was also for many years interested in another project for helpfulness, the building and equipping of an astronomical observatory as a memorial to Mr. Thaw and his son, and to Professor Langley's lifelong friend, Professor Keeler. For this institution $300,000 was raised, which is now one of the finest and best equipped observatories in the world. Through Mr. Brashear's efforts one department in the new observatory is free, and in the five years it has been open to the public no less than 14,500 people have made use of the telescope or listened to lectures on astronomy. Under the dome of one of the memorial telescopes, a mausoleum has been constructed by the friends of Mr. Brashear and Professor Keeler, in which lie the ashes of Professor Keeler and also those of Mrs. Brashear, who passed away in 1910. On the tablet covering the ashes of Mrs. Brashear are the words: "We have loved the stars too fondly to be fearful of the night."

Mr. Brashear was elected an Honorary Member of this Society in 1908. He is also an Honorary Member and Past-President of the Engineers Society of Western Pennsylvania and of the Royal Astronomical Society of Canada, an active member of the Royal Astronomical Society of Great Britain, the British Astronomical Society, the Société Astronomique de France, the Société Astronomique de Belgique, the American Philosophical Society, the American Astronomical Society, the American Association for the Advancement of Science, the Academy of Science and Art, and others.

He received the gold medal of the Franklin Insti-

tute in 1910; the degree of LL.D. from Washington and Jefferson, and Wooster Universities, the degree of D.Sc. from Princeton and the University of Pittsburgh, and that of Doctor of Engineering from Stevens Institute of Technology.

## THE ENGINEERING FOUNDATION

A noteworthy incident in the history of the profession of engineering in the United States will be the inauguration of The Engineering Foundation on January 27, 1915, in the auditorium of the United Engineering Society in New York.

The Engineering Foundation is the name given to a fund to be administered for the advancement of the Arts and Sciences connected with Engineering and the benefit of Mankind, the basis of which is the initial gift of a considerable sum by a noted engineer for this purpose. The American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers are to be represented equally in the administrative Board of The Engineering Foundation by election by the Board of Trustees of the United Engineering Society, which had been made the custodian of the fund. All members and friends of the engineering profession are invited to these inaugural ceremonies.

## SUGGESTIONS FOR AMENDMENT TO C-50 OF THE CONSTITUTION AND BY-LAWS

The following letter has been sent to the members of the Council:

December 18, 1914

To the Members of the Council
of The American Society of Mechanical Engineers

Gentlemen:

At meetings of the Council held November 13 and December 1, 1914, the following resolutions were passed:

*Resolved:* That it is the sense of the Council that the present method of nominating officers of the Society be amended, and request the Committee on Constitution and By-Laws to prepare such amendments to the Constitution and By-Laws as may be necessary in order to permit members to express their choice for nominees.

Constitution and By-Laws

*Voted:* That members of the present Council be requested to file with the Secretary for reference to the Council and Committee on Constitution and By-Laws, suggestions concerning any needed changes in the Constitution and By-Laws.

Under this action of the Council will you kindly send to the Secretary of the Society to be transmitted to the Committee on Constitution and By-Laws any suggestions which you would like to have considered by the Committee.

You would greatly facilitate the work of the Committee if we could have your suggestions in the hands of the Committee before January 20.

Yours very truly,

Calvin W. Rice, *Secretary.*

## COUNCIL NOTES

December 1

At a meeting of the Council on December 1 a committee was appointed by the President to report at the next meeting suggestions as to the Local Meetings of the Society. This Committee consisted of F. R. Hutton, Chairman, A. M. Greene, H. G. Stott and W. F. M. Goss.

The following appointments of Honorary Vice-Presidents were confirmed: Annual Meeting of the American Society of Refrigerating Engineers, Dr. Chas. E. Lucke; Pan-American Scientific Congress, committee to coöperate with the Department of State, General Wm. H. Bixby, Chas. T. Plunkett, and the Secretary.

The report of the Committee of the John Fitch Memorial was received and placed on file.

The matter of the bequest of Rear-Admiral Melville which provides for the Melville prize medal for original work was referred to the Finance Committee.

It was voted to authorize the President to coöperate with the American Institute of Mining Engineers and to make appointments on a joint committee on turbo-blowers.

December 4

At a meeting of the Council on December 4, the new officers were formally introduced.

It was voted that, in accordance with resolutions adopted by the committee appointed to consider and report on Local Meetings of the Society, a Committee on Sections, consisting of five members, be appointed by the Council which shall confer with the various sections and promote their interests.

In this Society it has always been customary to elect as officers of the Society and to appoint as members of committees the most eminent men in the profession, with the definite understanding that the actual labor of the committee shall be performed by the Secretary and a competent staff.

This is in distinction from all other societies which have succeeded in getting sufficiently able and representative men who not only have served on the board and committees, but themselves have performed the work or had it done without expense to the society.

In order to insure that what is done may be performed as efficiently as possible, it was voted that a committee, to be known as the Committee on Administration, be appointed, to investigate and report upon the economical operation of the Society's administration.

It is to be hoped that as time goes on the members will feel that they owe it to their profession to give their services to such an extent that they shall personally undertake the duties of the various committees on which they are appointed and thus perform the work better than any one that can be employed, and in the discussions on the meetings of the Society the em-

phasis will be on the thing to be accomplished and not on its cost.

John R. Freeman was appointed a member of the Board of Trustees of the United Engineering Society, to succeed Fred J. Miller, whose term of office has expired and who, having served one term, was under the Constitution not eligible for re-election.

Dr. John A. Brashear was reappointed to succeed himself as representative on the John Fritz Medal Board of Award, to serve for a term of four years.

It was voted that the Publication Committee be requested to prepare a circular regarding the form of publication of The Journal and the continuance of the publication of the Transactions in its present form, to be submitted to the membership for letter ballot in accordance with the vote of the Annual Meeting.

The following Executive Committee of the Council was appointed for 1915: John A. Brashear, President, Chairman; H. L. Gantt, Vice-Chairman; A. M. Greene, Jr.; Henry Hess; Spencer Miller; H. G. Reist; and James R. Sague.

Calvin W. Rice, *Secretary.*

## BOILER INSPECTION IN RUSSIA

In connection with the work of the Committee on Boiler Specifications, a statement secured by the editor of the Foreign Review of boiler inspection in Russia is of interest. The main work of boiler inspection is concentrated in the hands of the Ministry of Manufactures which carries it on through its factory inspectors. As the main work of the factory inspection in that country is concerned with the supervision of the proper application of the rather complicated and strict labor laws, there has been a feeling for a long time that it would be best to select the inspectors from men who had had training in legal and economic questions, but the fact that the inspectors had to inspect the boiler equipment of factories limited their selection to graduates of engineering schools exclusively. As a result, a law has been recently worked out for referring the entire matter of boiler inspection to Boiler Inspection Associations, which are private organizations, but which operate under government supervision.

At the same time, there is a pronounced tendency to make the boiler inspection laws more uniform than they have been hitherto. While the laws generally extended to the entire country, there has been a certain lack of uniformity due to the fact that certain plants have been under the supervision of the Ministry of the Interior, and others, especially boiler plants on river and canal steamers, under that of the Ministry of Ways of Communication, these two ministries often promulgating regulations different from those of the Ministry of Manufactures, which governed the inspection in the majority of factories. The regulations published by the Ministry of Ways of Communication in 1913 for "the installation and testing of boiler and steam piping on vessels on internal waterways," are in closer agreement with the rules of factory boiler inspection than have been the case hitherto, and it is expected that, as soon as the war is over, a uniform boiler code will be adopted for the entire country.

## GREETINGS FROM DR. BRASHEAR

It was a pleasure to receive at the Christmas season a telegram containing greetings from President Brashear, and through the medium of The Journal these are extended to the membership at large. The telegram reads as follows:

Dear Mr. Rice:

May I send through you my most kindly Christmas greetings to every member of the A.S.M.E. and all affiliated societies, wishing them health, happiness and prosperity, and may all have an ever present spirit of helpfulness in the great work, but pushing outward the borders of human knowledge.

Always cordially yours,
John Alfred Brashear,
Member of the Other Fellows Club

## A STUDENT BRANCH CONFERENCE

During the Annual Meeting of the Society in December a conference was held on the subject of the Student Branches of the Society. Prof. F. R. Hutton, Chairman of the Committee, presided. The interchange of experience and discussion of the differing problems of each institution was thought of such value that it was decided that a similar conference should be made part of the program of every Annual Meeting:

The topics broached covered:

(1) The advisability of having the Society office notify each member of a branch of his election to such membership

(2) The advantage of a diploma or certificate of membership; or of a button or lapel-badge

(3) The difficulties when Seniors only were members of a student branch in a transmittal of an èsprit de corps to the succeeding class

(4) The possibilities of using The Journal of the Society in seminar work of teaching

(5) The advantage of beginning an academic (and a branch) year by a social meeting at which also some outside engineer should speak and refreshments be a feature

(6) The advantages of stimulating participation of the student himself by paper and by discussion, even if the plan of getting talent from outside had to be curtailed to accomplish this result. Case School accepts papers presented before the branch as equivalent to required work for the degree, when of satisfactory quality

(7) The ideal (of Brooklyn Polytechnic Branch) of making the branch tell both for the engineering education of the members and for their so-

cial intercourse and their becoming "experts in friendship"

(8) The use of the stimulus of prizes for student papers before the branch (Hess Prizes) in promoting research work in laboratory or library and outside of the required curriculum for the degree

(9) Query raised: Does the requirement of a $2 subscription for the A.S.M.E. Journal keep any man from joining a Student Branch?

(10) Can students in course be members of the branch organization without paying a $2 Journal subscription?

(11) Suggestion offered: That one address per year by an A.S.M.E. member of experience be a feature of branch life; that a booklet covering the advantages of membership in a Student Branch be prepared by the Society, and it be made the duty of the professor who is honorary president of the branch to see each spring that these get into the hands of the class becoming eligible to membership; that lower classmen be always invited to branch meetings, while right to office and to vote be prerogatives of the upper classmen.

(12) One institution has a society of students for each year, the topics being chosen and pursued with some regard to the advancement in the course of study. The senior society becomes the A.S.M.E. branch by promotion, and hence a pride is felt in the branch, because it has been looked forward to

(13) That the A.S.M.E. invite the Student Branches to send delegates as such to the Annual (or semi-annual) Meeting of the Society, such accredited delegates to have the rights of members in attendance

(14) That a reunion of such delegates and of the honorary chairman of the branches be a stated feature of Society conventions

(15) That a report and summary of the meeting be published in The Journal for the information of Student Branches and their officers.

(16) That the Student Branches are potentialities of great mutual service, to the men and to the Society

F. R. H.

## JOURNAL ANNOUNCEMENT

During the past year The Journal has been made to include the Transactions of the Society, comprising papers and discussion given at the Annual and Spring Meetings and many of the papers given at local meetings of the Society. The Annual and Spring Meeting papers have been published in full, except in cases where they have been previously printed in earlier numbers of The Journal.

In the provision which has been made for binding, it was decided to include in the bound volume the papers and discussion mentioned above, and in addition the Review Section which contains abstracts of articles published in the foreign press and the proceedings of engineering societies. As announced elsewhere, covers for binding will be supplied for 75 cents. Any member ordering a cover may have the item charged to his account.

As announced in the December Journal, however, the Council has voted to continue the annual volume of Transactions in its original form in library binding for at least another year, so that members will receive in this volume as heretofore the papers and discussion given at the Annual and Spring Meetings, which will duplicate the reports of these meetings as published in The Journal. The additional matter in The Journal, which will not be contained in Transactions, consists of the monthly meeting papers and the abstracts of articles in the Review Section.

For the coming year, in view of the decision to publish Transactions as a separate volume, the papers and discussion will be printed in The Journal in abstract, as has been done in the present issue. The object will be to present to the membership in a brief and comprehensive form reports of meetings as soon as possible after they have taken place, so that it will not be necessary to wait until the end of the year before receiving this information.

All members are asked to give particular attention to this method of handling the publications of the Society, as in accordance with the resolution adopted at the Annual Meeting they will be asked to express their preference in the near future.

## APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are subdivided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of anyone whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before February 10, 1915.

## NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Alrich, Herbert W., Asst. Engr. of Constr., Consolidated Gas Co., New York

Barden, Julius C., Assoc. Dir., Bureau of Inspection and Accident Prevention, Aetna Life Ins. Co., Hartford, Conn.

Barrett, William F., Cons. Engr., Chicago, Ill., and New York

Bean, Clarence H., Asst. Supt. Motor Pwr., Armour & Co., Chicago, Ill.

Blake, Frederick W., Genl. Mgr., United Railways of Yucatan, Yucatan, Mex.

Dadley, James W., Efficiency Engr., The Celluloid Co., Newark, N. J.

Dierman, William, Pur. Agt., Society of Electrical Lighting, Paris, France

Duff, Howard, First Asst. Chief, Testing Bureau, Brooklyn Rapid Transit Co., Brooklyn, N. Y.

Ferguson, Smith F., Cons. Engr., Nicholas S. Hill Jr., and S. F. Ferguson, New York

Ford, Henry, Pres., Ford Motor Co., Detroit, Mich.

Francis, Ira J., With John A. Roebling's Sons Co., Los Angeles, Cal.

Gilmore, Thomas N., Ch. Engr., Westinghouse Church Kerr & Co., New York

Hamilton, Henry A., Asst. Mgr., Mengel Box Co., Jersey City, N. J.

Hardy, Clement A., With Whiting Foundry Equipment Co., Harvey, Ill.

Hosford, William F., Engr. of Methods, Western Elec. Co., Chicago, Ill.

Kellogg, Raymond M., Asst. Engr., Gas Dept., Westchester, Ltg. Co., Mt. Vernon, N. Y.

Kennedy, James S., Supt., Standard Gas Light Co.'s Wks., New York

Larson, Gustus L., Prof. Mech Engrg., Univ. of Idaho, Moscow, Idaho.

Leach, Ralph W. E., New England Rep., American Engrg. Co., Boston, Mass.

Lemley, Benjamin W., Vice-Pres., Coats & Burchard Co., Chicago, Ill., and Supvg. Engr., Constr. Dept., General Elec. Co., Cleveland, Ohio

Loizeaux, Alfred S., Elec. Engr. and Supt of Constr., Consolidated Gas Elec. Lt. & Pwr. Co., Baltimore, Md.

Nixon, Boyd, Pacific Coast Rep., Eastern Mch. Tool Builders, Glassboro, N. J.

Platts, Charles A., Transportation Engr., Boston Branch, The Kelly-Springfield Motor Truck Co., Cambridge, Mass.

Quinn, Stephen M., Elec. Constr., Dodge Brothers, Detroit, Mich.

Roueche, William L., Supt. Pipe Shop, Crane Co., Birmingham, Ala.

Smith, Merrill Van G., Prof. of Mech. Engrg., Delaware College, Newark, Del.

Stone, William G., Whitesboro, N. Y.

Thompson, John L., Supvg. Engr., Travelers Ins. Co., & Travelers Indemnity Co., Hartford, Conn.

Whiton, Herbert S., Supt. Manuf., Minneapolis Genl. Elec. Co., Minneapolis, Minn.

Williams, Harold E., Vice-Pres., Railway Materials Export Corp., and Eastern Rep., Pyle-National Elec. Headlight Co., New York

Younger, John, Ch. Engr., Truck Dept., Pierce Arrow Motor Car Co., Buffalo, N. Y.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Allen, J. Wallace, Asst. Ch. Engr., New Castle Wks., American Sheet & Tin Plate Co., New Castle, Pa.

Chesnutt, Ralph C., Ch. Designer, Aurora Automatic Mchy. Co., Chicago, Ill.

Clarkson, Ralph P., Prof. of Engrg., Acadia Univ., Wolfville, N. S., Canada

Coe, Harry L., Mech. Engr. and Mem. of Firm, Harpham, Barnes & Stevenson Co., Boston, Mass.

Dunton, Philip R., Supt. Municipal Water & Light Plant, Ponca City, Okla.

Eidmann, Frank L., Instr. Dept. of Mech. Engrg., Rensselaer Poly. Inst., Troy, N. Y.

Flack, Alonzo, With The Emerson Co., New York

Hale, Henry A., Jr., Mgr. Bureau of Safety, American Mut. Liability Ins. Co., Boston, Mass.

Hamilton, William P. B., Mech. Engr., Mengel Box Co., Jersey City, N. J.

Miller, Sereno G., Prin. Mech. and Engrg. Dept., New Bedford Textile School, New Bedford, Mass.

Pope, Joseph, Mem. Station Betterment Div., Stone & Webster Engrg. Corp., Boston, Mass.

Tillman, Richard H., Indus. Engr., Consolidated Gas, Elec. Lt. & Pwr. Co., Baltimore, Md.

FOR CONSIDERATION AS JUNIOR

Allison, Laurence M., Mech. Draftsman, Iola Portland Cement Co., Iola, Kan.

Gibbs, Paul H., Mech. Engr., Belknap Mfg. Co., Bridgeport, Conn.

Hassell, Hube, Machinist, Tennessee Central R. R. Co., Nashville, Tenn.

Henry, William M., Treas. and Engr. of Production, Henry & Allen, Auburn, N. Y.

Kroeschell, Robert A., Engrg. Dept., Kroeschell Bros. Ice Mch. Co., Chicago, Ill.

Leistner, August, Operator, Pwr. Plant, Hudson & Manhattan R. R. Co., Jersey City, N. J.

Link, Edgar W., Testing Dept., The Westinghouse Mch. Co., East Pittsburgh, Pa.

Lutze, Jay H., Designer, The Bristol Co., Waterbury, Conn.

Manker, Forrest W., With B. F. Sturtevant Co., Boston, Mass.

Maverick, Lewis A., Asst. Sales Mgr., Germania Refrigeration & Mchy. Co., Belleville, Ill.

Penniman, Abbott L., Jr., Supt. Steam Stations, Consolidated Gas, Elec. Lt. & Pwr. Co., Baltimore, Md.

Scriven, Albert K., Shop Foreman, Easton Mch. Co., South Easton, Mass.

Simon, Cecil S., Machinist, Drum Pwr. Plant, Pacific Gas & Elec. Co., San Francisco, Cal.

Smith, Peter M., Mech. Draftsman, The William Tod Co., Youngstown, Ohio.

Spofford, Harry H. R., With Schutte & Koerting Co., Philadelphia, Pa.

Thornhill, W. H. T., Estimator, Midvale Steel Co., Philadelphia, Pa.

Williams, Harold J., Instr. Applied Mechs., Pratt Inst., Brooklyn, N. Y.

Woolner, Seymour A., Pur. Agt., Woolner Distilling Co., Peoria, Ill.

## APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Kruesi, August H., Engr. of Constr., General Elec. Co., Schenectady, N. Y.

PROMOTION FROM JUNIOR

Faile, Edward H., Supvg. Engr., Adams Express Bldg. Co., New York

Swarts, Guy T., Vice-Pres. and Ch. Engr., Steam Equipment Mfg. Co., Pittsburg, Pa.

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# THE ANNUAL MEETING

## HELD AT THE SOCIETY HEADQUARTERS, NEW YORK, DECEMBER 1—4

*THIS meeting, which was one of the most successful in the history of the Society, was notable for the unusual number of papers devoted to many branches of engineering. Interesting papers were contributed on subjects in Industrial Engineering, Textiles, Machine Shop Practice, Railroad Engineering, Public Service, Iron and Steel, Hoisting and Conveying, Cement Manufacture, etc., and unusual interest was shown in all the sessions, of which there was a total of fifteen. One of the most important features of the meeting was the discussion of the Progress Report of the Boiler Specifications Committee, which occupied six sessions. The attendance at this meeting was the largest in the history of the Society.*

The thirty-fifth Annual Meeting of the Society, held December 1-4, 1914, in the Engineering Societies Building, New York, was notable for its unusually large number of professional papers and technical sessions, and for the discussion of the preliminary report of the Boiler Code Committee, the latter alone extending through six sessions. In all a total of 27 papers were read, besides the address of President Hartness on Tuesday evening, and 15 sessions were held, including those on the Boiler Code, there being sometimes three simultaneous sessions under way, and on Thursday afternoon four were in progress at the same time. The papers covered a wide range of subjects and were effective in drawing a large audience. The attendance at the meeting was the largest in the history of the Society, the total registration being 1367, of which 821 were members.

MAIN AUDITORIUM OF THE ENGINEERING SOCIETIES BUILDING WHERE THE LARGER OF THE PROFESSIONAL SESSIONS ARE HELD

The social features of the meeting, under the supervision of the House Committee and the Committee on Meetings of the Society in New York, were attractive and well attended. The usual presidential reception was held in the Society rooms on Tuesday evening with a large attendance, and on Wednesday afternoon the rooms were the scene of a successful reception and thé dansant given by the Ladies' Committee, Mrs. Edward Van Winkle, Chairman. The chief social event came on Thursday evening at the Hotel Astor, where the annual reunion took the form of a dinner dance. More than 300 covers were laid in the grand ball room, the guests progressing from table to table for the various courses. There was dancing between courses as well as at the conclusion of the dinner. This dinner dance was an innovation which apparently was very pleasant to every one and many expressed the hope that it might be made a permanent feature of the Annual Meetings. Unlike the usual dinner or formal reception, it gave every person present an opportunity to meet a large number of others and the event pro-

moted sociability to the greatest possible degree. Another delightful occasion was the luncheon tendered to the ladies of the Society on Thursday in the Orangerie of the Hotel Astor by Mrs. Harrington Emerson, which was attended by about 125.

The presentation of the John Fritz Medal on Wednesday evening, together with the interesting addresses given by Dr. James Douglas, Honorary Member and Past-President of the American Institute of Mining Engineers, and Dr. S. W. Stratton, director of the Bureau of Standards at Washington, proved to be another interesting feature. A more complete account is given elsewhere in The Journal.

In connection with the meeting, the engineering alumni of nine colleges held reunions on Friday evening, following the practice of last year.

### OPENING SESSION

On Tuesday evening, President James Hartness gave his address on the subject, The Human Element the Key to the Economic Problem. This address presented an analysis of the human characteristics that influence a man in his various efforts, and especially his accomplishments in industrial work, and showed the bearing which these same characteristics have on the industries themselves. He contended that large organizations are essential and that rightly conducted they are beneficial, since they seem to provide more nearly the conditions required for the happiness and success of the workman, when we come to analyze what the workman actually needs to inspire his best efforts.

Preceding the address there was a report given by the tellers of election of officers, showing the following votes cast: For President, John A. Brashear, 2034; for Vice-Presidents, Henry Hess, 2031; Geo. W. Dickie, 2033; James E. Sague, 2034; for Managers, Charles T. Main, 2035; Spencer Miller, 2036; Max Toltz, 2032; and, to fill the unexpired term of the late Alfred Noble, Morris L. Cooke, 1171, George J. Foran, 859; for Treasurer, Wm. H. Wiley, 2034.

An abstract of President Hartness' address follows, and the complete report will be published in the next volume of the Transactions.

### ABSTRACT OF THE PRESIDENT'S ADDRESS

The world of mechanism has become so intricate and complex that it has gone beyond the capacity of any single individual. Each one must be content to comprehend only a small part, and only by selecting the character and limiting the amount of material that is taken into our individual minds can we hope to accomplish the best results. Under ordinary conditions the mind receives impressions from all directions, which, if unguided, may result in an undesirable trend in our personality and ability. On the other hand, by concentrating on those things which are of the greatest use to us, keeping in mind the laws of psychology, we may make a better use of our mental energy. The engineer should devote a part of his time to the care and study of his thinking machine instead of devoting it all to the machine created by that thinking machine. We should not overload our minds with data to the exclusion of thoughts of an initiative character.

Man is a creature of habit to an extent that renders this characteristic a dominant one, and the most efficient use of mind and body demands a scheme of life that permits each one to take advantage of this fact.

Specialization and repetition, by which habit is formed, are both essential to success. Carrying the principles of the individual into the realm of organized industry, it is a fact that large organizations are essential as affording an opportunity for the most complete sub-division of work and the greatest degree of specialization, both of which lead to the most effective employment of human energy. A most important element of the large manufacturing plant is its organization. Without this, the buildings and equipment are of little value. Antagonism to the large organizations should be directed against corrupt practices, and not against the organization itself, which involves the workers' interest. The greatest good to the greatest number requires that we take into consideration each human being, his desires and his needs in finding the work for which he is best endowed.

Granting that the large organization is essential in this age, not only in bringing out the best in the individual but in maintaining the supremacy of American industry against foreign competition, may it not be that we may approach the ideal which we may assume to be somewhat as follows for a large industrial plant:

It should have a capital equal to or as large as any competing organization. If possible it should have a small harmonious board of directors with an able leader. But if the directors merely represent the monied interests without special knowledge of the industry, then it would be sufficient if they were capable of appointing an able staff of officers, the chief executive of which should combine a knowledge of the technical and business side of the industry with the fullest possible conception of the human element. He should stand firmly for the cardinal principles of industrial economics as based on the human characteristics. Each officer should possess some special knowledge essential to the organization, so that the combined staff would have a general knowledge of all the various branches.

The chief executive should make it known that long continuity in service of each man in office will be given the first place in the scheme of management, and this should not only include the officers, but it should be the key to the management of the entire organization.

The period of years of service of each man in the organization in a given task or in a given office should compare favorably with competing organization.

It should be the aim of the executives to fill each position throughout the entire organization with someone who considers that position the best place in the world for him. Each officer and each workman should have a live interest in his part of the work. Each one should by specialization become the most efficient in his particular work. The interest of the officer or worker should be maintained by some fitting stimulus, and each one should be protected so far as possible from influences calculated to induce discontent.

Each man should be treated in a respectful manner. Needless direction or heartless correction by an overbearing executive should not be permitted. Criticism or reprimand should not be uttered in the presence of others, for the best control of the organization comes from contact with the better side of man, and that side is not reached by one who rides rough-shod over a man's self-respect.

Personal dignity and self-respect is an important characteristic in everyone. It is not the exclusive quality of those whose self-respect is very apparent, nor is it limited to those whose natural conduct and bearing indicate their high regard of the esteem of others. It is to be found in the entire human family, and he who fails to see it, even in an apparently careless person, is blind to a very important part of the human spectrum.

As these truths become known will it not be possible to formulate general rules of management of industrial organizations that will be of great value to both the investor and the promoter? With such rules the investor could see to what extent an organization conforms to success standards. There would be in addition to the regular treasurer's report a human report. The human report would begin with a description of the directors and go through the entire organization. This report would contain a statement regarding the elements of harmony of organization; of length of service of manager and workers; the frequency of change of methods or article manufactured; intelligence of executives in the management of men; the degree of contentment of each member; the extent to which each man in the organization approaches the best position for which he is endowed and how nearly he obtains the best remuneration for which he is qualified; the extent to which the management recognizes the inertia of habit of both mind and body; the degree in which the various men in the organization approximate the condition of highest efficiency; the extent to which the management goes in expression of appreciation; the degree of its knowledge of the most important characteristics of man as indicated by his inner motives and desires and the condition of his mind as he goes to his home at night. No mention is made here of the conditions of buildings from the point of sanitation and comfort, for such conditions are now closely scanned; but mention has been made of a few of those other conditions that must some day be measured just as we now measure power and other less vital things.

All of these elements should be carefully appraised and the average should be the rating of the company. The investor who considers this human rating with the treasurer's statement will seldom make a mistake in estimating the true worth of an industrial organization.

May we not hope that tabulations of these various elements taken from a variety of industries will lead to establishing a standard that will be a guide to both the manager and the investor?

Surely the investor should look with distrust upon a management that is always changing officers, changing men, changing models, changing methods without regard to the inertia of habit and the human element which is the life blood of every organization. He would also look with doubt on any scheme of management that allows the careless employment and discharge of men without due regard to the loss involved by such changes, for the perpetual changing of men is equivalent to the change of character of work in its handicap to industrial efficiency.

### WEDNESDAY MORNING SESSION

The annual business meeting occupied the session of Wednesday morning, and the annual reports of the Council and Standing Committees were presented by the Secretary. The committee reports were printed in the December issue of The Journal and the Council report will appear in Volume 36 of Transactions.

In presenting the report of the Council the Secretary called attention to the varied work which the Society is successfully carrying on. Standardization work has been actively followed by the committees on flanges, pipe threads, boiler specifications; dimensions in screw threads; threads for fixtures and fittings; changes in the patent laws of the United States; specifications for fire hose and the tests for hose; power tests, a most voluminous report comprising standard methods for testing prime movers and all types of auxiliary apparatus; researches into the subject of standardization of safety valves; and standardization of commercial filters.

As a further development of the Society's work and a part of the work of the Committee on Meetings, subcommittees are at work in a great variety of branches of the engineering profession, such as the science of administration, cement, fire protection, air machinery, depreciation and obsolescence, hoisting and conveying, industrial building, iron and steel, machine shop practice, railroads, textiles, and a new committee on protection of industrial workers. Five of these committees have produced papers or reports for the Annual Meeting. It is the expectation that eventually all committees will not only make comprehensive reports on the progress of their branch of engineering, but fur-

nish one or more specific papers of major importance. It is thus intended that the Transactions shall contain each year an authoritative review of the state of the art.

Reading Room

The views on this page show the three large connecting rooms at the headquarters of the Society which when thrown together provide a spacious and attractive gathering place for many of the social events of the Annual Meeting. Here the President's Reception and the Ladies' Reception were held

Prof. F. R. Hutton presented a report of the Committee on Society History, describing what the history would aim to do, and stating that it had been found necessary to issue it by subscription. The manuscript has been prepared by the painstaking labor of Professor Hutton whose familiarity with every detail of the Society's activities from its organization has made it possible to introduce a great deal of matter of general interest beyond what is included in the formal

Secretary's Office

records of the volumes of the Transactions. The text is enlivened by an account of many incidents relating especially to the early meetings of the Society by which the personal characteristics of the small group constituting the membership are vividly portrayed. Of perhaps still greater interest is the historical development of policies and precedents in the Society which have grown up with the years and which are somewhat apart from matters of definite history in the usual sense.

I. E. Moultrop then reported for the Committee on Increase of Membership and outlined its work. During the fiscal year 1913-1914, 1195 applications have been received, making a gain of over 14 per cent more than were received during the previous year. During the four years since the establishment of the committee, 3418 applications have been received, a number almost equal to the total membership, 3899, of the Society previous to that time.

Mr. Moultrop laid stress on the importance of welcoming the large number of new members who are coming into the Society. At every convention there are new faces and it is difficult to remember names where members have been met only once or twice before, and he knew that every effort would be made to introduce such members and to give them a hearty welcome to the convention. To this end the plan had been adopted of giving to each new member a blue ribbon to wear in his lapel and all the older members had been requested to greet and introduce these new members.

Council Room

The amendment to C-45 of the Constitution relating to the addition of a standing committee on Standard-

ization was then read by the chairman of the Committee on Constitution and By-Laws, Jesse M. Smith, and ordered by the meeting submitted for letter ballot.

The following resolution was then adopted:

Resolved: That the form of publication of The Journal and the continuance of the publication of the Transactions in its present form be made the subjects of a referendum mail vote to the membership of this Society and that the form of letter ballot be decided upon by the Council.

The remainder of the meeting was devoted to a discussion of the Boiler Code, reported elsewhere in this issue.

### PROFESSIONAL SESSIONS

The professional sessions will be reported in detail in this and succeeding issues of The Journal, with a more complete printing of the papers and discussion in the annual volume of the Transactions. As in recent years, the Committee on Meetings has aimed to have sub-committees in charge of sessions or at least to submit papers in their respective fields, and this year there were papers offered by five committees, and an all-day session on Thursday on the Relation of the Engineer to Public Service in Municipalities, in charge of the Public Relations Committee of the Society, was made the feature of the convention. This meeting was opened by the Hon. John Purroy Mitchel, Mayor of the City of New York, and many prominent members of the Society were on the platform, among them Andrew Carnegie who at the close of Mayor Mitchel's address made a few humorous remarks, to which President-Elect Brashear, an intimate friend of Mr. Carnegie, retaliated in kind.

The sessions were well attended and the capacity which the Society has developed for conducting professional meetings was well illustrated on Thursday afternoon when there were two largely attended sessions in progress simultaneously, besides a session on the subject of Cement Manufacture with 40 or 50 present, and a meeting for the discussion of the Boiler Code with an attendance of 100.

The following is a list of the papers presented during the convention:

Floor Surfaces in Fireproof Buildings, Sanford E. Thompson.

Reinforced-Concrete Factory Buildings, F. W. Dean.

Measuring Efficiency, H. L. Gantt.

Standardization in the Factory, C. B. Auel.

Operation of Grinding Wheels in Machine Grinding, Geo. I. Alden.

Friction Losses in the Universal Joint, P. F. Walker and W. J. Malcolmson.

Steam Locomotives of Today: Report of the Sub-Committee on Railroads.

The Future of the Police Arm from an Engineering Standpoint, Henry Bruère.

Some Factors in Municipal Engineering, Morris L. Cooke.

The New Charter for St. Louis, Edward Flad.

The Engineer and Publicity, C. E. Drayer.

Snow Removal: A Report of the Committee on Resolutions of the Snow Removal Conference held in Philadelphia, April 16 and 17, 1914.

The Design and Operation of the Cleveland Municipal Electric Light Plant, Frederick W. Ballard.

The Handling of Sewage Sludge, George S. Webster.

Training for the Municipal Service in Germany, Clyde Lyndon King.

A Study of Cleaning Filter Sands with no Opportunity for Bonus Payments, Sanford E. Thompson.

Factors in Hardening Tool Steel, John A. Mathews and Howard J. Stagg, Jr.

Standardization of Chilled Iron Crane Wheels, F. K. Vial.

The Mechanical Elimination of Seams in Steel Products, Notably Steel Rails, R. W. Hunt.

Topical Discussion on Alloy Steels.

A Rate-Flow Meter, H. C. Hayes.

Laboratory for Testing and Investigating Liquid Flow Meters of Large Capacity, W. S. Giele.

A New Volume Regulator for Air Compressors, Ragnar Wikander.

Physical Laws of Methane Gas, P. F. Walker.

The Clinkering of Coal, Lionel S. Marks.

Damages for Loss of Water Power, F. W. Dean.

### EXCURSIONS

A number of interesting and instructive excursions were arranged by the committee in charge, John P. Neff, Chairman, and proved unusually successful.

A party of 20 made the trip to Ellis Island on Wednesday morning, under the guidance of H. R. Cobleigh, and were shown through all the departments of the immigrant station. The visitors were particularly interested in the tests which are applied to the immigrants to determine the desirability of admitting them, and also in the restaurant where the immigrants are fed at a cost of 24 cents a day. Leaflets placed in the hands of each visitor gave briefly the salient features of the building and the methods pursued in the work.

The Hill Building was visited by a party of 25 on Wednesday afternoon, C. W. Dibble acting as guide. This is the heaviest and most substantial building of its size in New York, not a single piece of wood entering into its construction. It is essentially a printer's building, and although only 12 stories in height is as tall as an ordinary 17-story building. The building is sealed, all air being filtered and washed before being forced to the different floors. The three intake fans handle 47,000 cu. ft. of air per minute, while the two exhaust fans on the roof handle 67,000 cu. ft. per minute. Drinking water is filtered, cooled in an ice plant, and supplied to bubblers on each floor. A pressure sprinkler system is used throughout, and in addition there are two automatic fire alarms on each floor connecting directly with a firehouse less than a block away. The office floor of the Hill Company is completely covered with interlocking rubber tiling, which almost eliminates all noise of walking, and in addition to this Noiseless typewriters are used. Machine dictation is used exclusively. All the furniture except the chairs is of steel, and the lighting is entirely indirect. The building has its own power plant, containing three 250-kw. Erie City engines of the Lentz type. The

boiler plant is of Heine boilers, equipped with Taylor stokers, and so arranged that there is no necessity for shoveling coal. This is delivered to the stokers by a bucket, working direct from the coal bunkers, and the ashes are removed by vacuum and carried up into an ash container where they are automatically sprinkled. They fall by gravity into ash carts driven under the ash storage. Buses provided by the company conveyed the party to and from the building.

A party of 38 visited the new long distance telephone office on Walker Street on Wednesday afternoon, conducted by Francis P. Davis. Upon arriving at the building the party was divided into groups of five, with three guides to each. This office was put into service during January 1914, and is the largest and most modern long distance exchange in the world. The switchboard consists of more than 200 operators' positions, occupying two entire floors in a large fireproof building, and handling approximately 13,000 outgoing and incoming calls per day. An interesting feature consists of a pneumatic tube system by means of which tickets containing information in regard to calls are carried from one part of the office to another. Much interest was taken by members of the excursion in the provision made by the company for the welfare of the operators.

Through the courtesy of Rear-Admiral N. R. Usher, Commandant, 90 members made an interesting trip to the Brooklyn Navy Yard under the guidance of W. P. Hayes and E. S. Cooley. The tug Powhattan had been placed at the party's disposal, and the visitors were conveyed from the foot of East 23rd Street to the Navy Yard, thus making a novel approach. They were shown through the machine shop, boiler shop, foundry and power house and noted the various points of interest. Three submarines were also seen in drydock and a comparison with the original Holland submarine, mounted in the yard, showed what strides have been made in developing this type of vessel. The dreadnought Wyoming, of 26,000 tons burden, was then inspected. This has 12-in. rifles, 50 ft. in length, and its engine rooms are equipped with turbines developing 33,000 h.p. showing great compactness of installation. The dreadnought Rivadiva, just completed by the Cramp Shipyards for the Argentine Republic, was viewed as it went into drydock. This vessel is armored with twelve 12-in. rifles as well as numerous smaller caliber guns, and is fitted with a torpedo net. It develops a horsepower of 39,500. The party returned to Manhattan on the same tug. The various points of interest at the Navy Yard were explained by Lieut.-Com. S. H. R. Doyle, supervising the construction of the new dreadnought Arizona, by Lieut. C. A. Blakeley, in charge of the machine shop, and by Lieut. C. W. Nimitz, the naval expert on Diesel engines. Lieut. H. G. Shonerd acted as the general guide.

On Thursday afternoon a party of 135 visited the studio of the Biograph Moving Picture Company on 175th Street. The party was divided into three groups and shown through the building by Mr. J. J. Kennedy and his assistants. The building is five stories in height, of reinforced concrete and fireproof construction. The laboratories for developing, reproducing, etc., are on the top floor, as is also the large daylight studio with its immense glass dome, for use in fair weather. A number of different scenes can be taken at one time in this room. The artificial light studio is located on the third floor and is arranged for four stage settings. At the time of the visit three of the stages were in operation, and the visitors saw several rehearsals and the final production. Each scene is rehearsed until it can be carried through in the definite length of time allowed for the act, and two reels are taken of the finished product, one of which is preserved and the other developed. The light effect is produced by the mercury vapor lights, with tubes approximately four feet in length and arranged in batteries of 24 to 30. The batteries are on racks which can be shifted around in different positions and adjusted to produce practically any light effect required. The studio is working 20 hours out of each 24, as the demand for reels is greater than the company can supply, even with its force of 300 or 400.

On Friday morning an instructive trip was made by about 60 members to the United Electric Light & Power Company's generating station at 201st Street, J. H. Lawrence acting as conductor. Buses furnished by the company conveyed the members to the power station, and two hours were spent in inspecting the various equipment. This power house represents the latest type of power station design in this vicinity and is unique in that the main units and auxiliaries are all turbine driven. The plant will have a capacity of 120,000 kw., three units of 15,000 kw. each being at present in operation. There are 32 boilers of 650 h.p. each, with provision for 40 more if necessary. All of the boilers are equipped with the Metropolitan cinder catcher, which has proved very successful in this work. Luncheon was served to the visitors in the plant by the company.

Small groups also visited the Bureau of Municipal Research on Wednesday afternoon and the McCall Corporation on Thursday morning, R. V. Wright acting as guide in the latter case. It was expected that the members would have the opportunity of inspecting the S. S. Lusitania, but this proved to be impossible.

# WEDNESDAY AFTERNOON SESSION

## SYNOPSIS OF PROCEEDINGS OF AFTERNOON SESSION OF DECEMBER 2, 1914, OF THE ANNUAL MEETING

### FLOOR SURFACES IN FIREPROOF BUILDINGS

BY SANFORD E. THOMPSON, NEWTON HIGHLANDS, MASS.

Member of the Society

No one type of floor surface is adapted to all conditions, and having selected the proper type, the choosing of the materials and the manner of the construction govern to a large extent the durability of the surface.

It is the purpose of the paper to discuss briefly the different kinds of floor surfaces; indicate the types of construction which may be selected under different conditions; give approximate costs of various floor surfaces; describe tests and investigations of granolithic construction made in connection with the buildings for New Technology (Mass. Inst. Tech., Boston, Mass.); and present recommendations for granolithic construction.

Summarizing the discussion on the characteristics of floors:

*Granolithic Trowelled.* As ordinarily laid in buildings, granolithic or concrete surfaces are subject to dusting and under heavy traffic, such as trucking, are liable to serious wear. On the other hand, experience with first-class construction and tests of actual floors show that it is possible, by proper selection of the aggregates and expert workmanship, to reduce the dusting to an insignificant amount and to produce a surface hard enough to stand even severe wear. The chief objection to concrete or granolithic surfaces for offices, drafting rooms, classrooms, laboratories, etc., is that it is hard on the feet for men standing all day, tends to break tools dropped upon it, and is not adapted for attaching seats or other furniture. In certain colleges, however, concrete floors are used widely and are highly recommended. In one instance the men complained of coldness and hardness where the floor was laid directly on the ground, whereas, where there was a warm basement underneath no objection was raised. Cost, 5 cents to 7 cents per sq. ft.

*Granolithic with Ground Surface.* Experimental surfaces, together with laboratory tests made as a check, show that a pleasing surface, approaching terrazzo in appearance and fully as durable under foot traffic, can be obtained by placing granolithic with scarcely any troweling, and then grinding the surface just enough to expose the grains of sand and stone. It is suggested that this grinding might remove the objection of dust previously referred to. The extra cost is estimated not to exceed 3 cents per sq. ft.

*Linoleum.* The hardness and noise characteristic of granolithic finish are overcome by covering the surface with Battleship linoleum. The linoleum should be stuck firmly to the granolithic surface and preferably a cove base should be run around the room and sills provided at entrances so that the surface of the granolithic will be flush. In this way the edges are prevented from fraying. The life of first-class quality Battleship linoleum, if edges are not frayed, is probably from 15 to 30 years, depending upon the amount of travel. The cost, allowing for the better finish required on the concrete, is substantially the same as for a single floor of birch or maple. Cost, 18 cents per sq. ft., including 3 cents per sq. ft. for ¾ in. layer of mortar.

*Hardwood Floors.* Floors of maple, birch, beech, oak or long-leafed Southern pine, are used most largely for offices, classrooms, or lecture rooms, and in many of the older colleges for laboratories and halls. A wood surface, however, is not usually considered entirely satisfactory either in general appearance or in wearing qualities. There are various methods of laying hardwood floors. For classrooms a single thickness of maple or birch nailed to sleepers with cinder concrete between should be satisfactory. Another type of construction is to use patented metal screeds imbedded in the base concrete, and nail the floor boards to splines in the screeds. For rooms subjected to heavy traffic, 2-in. or 2½-in. plank may be placed underneath the hardwood floor. Cost 18 cents to 25 cents per sq. ft. based on a price of $45 per 1000 board measure.

*Terrazzo.* This is made by spreading upon the base concrete a mixture of neat cement and marble chips and grinding the surface to a depth sufficient to cut into the stones and expose them on their largest diameters. The joints between the particles, being of neat cement, are hard and even more durable than the pieces of the marble themselves.

Terrazzo is largely used, especially in the newer office buildings and in institutions, for corridors and halls. It also is satisfactory for lavatories, although more expensive than granolithic. It appears from the author's investigations that for both of these uses concrete with a ground surface can be substituted at less cost and with satisfactory results. Cost, 19 cents to 24 cents per sq. ft.

*Magnesium Composition.* Suitable for offices, class,

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Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

lecture and drafting rooms, and laboratories. If carefully laid it wears satisfactorily. Any imperfections are apt to show within the first year. It is more resilient than granolithic, less noisy, and furniture can be screwed directly to it. Colleges have used it extensively, especially for certain laboratories, and Cooper Union in New York City have many such floors proving satisfactory. Cost, 20 to 24 cents per sq. ft.

*Essentials of Granolithic Construction.* Aggregates should contain no dust but should consist chiefly of particles ranging from $\frac{1}{16}$ in. to $\frac{1}{2}$ in. in size.

Proportions with first-class materials should be one part cement to two parts aggregate.

This mixture should be of such consistency that it will not flow but will hold its shape in a pile without settling.

A perfect bond must be made with the base concrete either by laying the granolithic before the concrete has set, or else roughening surface and providing a bond of neat cement paste.

Laying must be done at moderate temperatures, avoiding temperatures below 50 deg. fahr.

Troweling should be thorough but no excess water should be brought to the surface. A hard, dense surface rather than a smooth, glossy surface should be the aim.

The surface should be kept wet for at least ten days to two weeks after laying.

*In General.* The paper contains also a table of approximate costs of the different floor surfaces, which are given more in detail than mentioned in the above summary. There are also a set of specifications for laying granolithic finish on set concrete and specifications for grinding granolithic surfaces.

## DISCUSSION

In presenting the paper the author said that good granolithic floors were being built which will stand very severe traffic and that will dust only to a very small degree. The five principal requirements are: Materials, proportions, bonding, methods of laying, and treatment of surface, if any. Use coarse material with the cement, avoiding fine sand or stone with fine particles because this rises to the surface in trowelling. Use a comparatively dry mix that will have to be put on with the aid of tampers. There are certain compounds on the market that will prevent dusting, but if the right materials and workmanship are employed, so little dusting will occur as to do no harm for ordinary purposes.

For durability it is best to lay the floor surface along with the base concrete. This is often almost impracticable and tests have proven that a good bond can be obtained on old concrete with the proper treatment. Special attention is called to the specifications given at the close of the paper to laying granolithic in cold weather.

Ross F. Tucker. So much difficulty exists in securing a good wearing surface for granolithic that hardwood is preferred for all purposes, particularly where operatives have to be on their feet.

L. C. Wason. The cost of granolithic quoted by the author is too high by 10 cents per sq. ft. There is also a difference of $3\frac{3}{4}$ cents per sq. ft. between hardwood floors 2 in. face by $1\frac{1}{8}$ in. thick as against $3\frac{1}{2}$ in. face by $\frac{7}{8}$ in. thick. Magnesium composition is also laid at a third less than quoted.

It has been found that factory operatives claim that lameness and fatigue are caused by granolithic floors being better conductors of heat and cold. This has been overcome where floors are cold by wearing heavy shoes.

Nalecod, another material composed of asbestos, portland cement and sand, is giving better results than screed for wood floors.

For a granolithic floor no particles should be used smaller than those passing a No. 30 sieve, and hard rock which will withstand abrasion should be used, without any sand, the proportion being one to two. It is also pointed out in bonding to old surfaces that a thin top, i. e., $\frac{3}{4}$ in. or 1 in., is more likely to come loose than a thicker one.

Commenting on Appendix No. 1, a multiple pick is cheaper and requires a less experienced workman than a bush hammer.

Dilute muriatic acid is unsafe unless the concrete is dense, otherwise it is likely to soften it.

The mixture should not be limited to granite, as traps and gravel give good results. A stiff mortar gives best results, although a different consistency should be used, depending on whether the base is fully set.

Much better results can be obtained by using a wood float than a steel trowel. Specification should read, Float granolithic surface as soon as it begins to stiffen. Commenting on Appendix No. 2, better results can be obtained with wet grinding than with dry.

G. S. Walker. There is almost certain to be trouble with granolithic if the base is allowed to set and an attempt afterward made to bond the surface to it. This is due to the shrinkage rate being different. They should always be laid together.

Walter S. Timmis. There is a very serious defect in wood floors in fireproof buildings, that of springiness. This was more apparent in the earlier buildings where floors were laid directly on the arches, but even in recent buildings it occurs, owing to care not being exercised in bringing the cinder fill to the top of the screed. Dry rotting of screed also often takes place, especially when the floor is laid before the cement is dry. On granolithic floors, the difficulty in getting a smooth surface and no dusting is due to the trowelling not being done at the psychological moment.

George P. Hemstreet in a written discussion, called attention to another form of asphalt floor for fireproof buildings, streets, piers, warehouses, etc., used for many years, viz., asphalt blocks composed of hard crushed stone and about 7 per cent asphaltic cement formed under hydraulic pressure of various sizes and forms. These are laid in cement mortar with joints grouted. The surface is smooth, resilient, non-slipping, dustless, sanitary and not easily marred. The cost is $1.50 to $2.50 per square yard.

The Author, in closing the discussion, agreed with Mr. Wason's description. Regarding bonding new to old, the

best answer is the fact that it has been done with good results due to the neat cement applied to the roughened surface which seems to overcome the theoretical difference in expansion and contraction.

## REINFORCED CONCRETE FACTORY BUILDINGS

By F. W. Dean, Boston, Mass.
Member of the Society

The reinforced-concrete factory building is in considerable favor at present and is likely to be increasingly so. It is fireproof and gives the maximum resistance to fire. Other merits are the possibility of greater window area over the regular mill construction, the light color of the ceilings and adaptability for heavy floor loads without requiring narrow bays.

There are two general types of floor construction, one with beams, the other with smooth ceilings known as the mushroom construction. For factories, especially when lineshafts with large pulleys are used, the beamed construction is preferred, while for storehouses and machine shops with light motor-driven machines the smooth ceiling is better. The strains in the mushroom system are more uncertain but, in practice, no inconvenience or risk arises.

In the beam system the building as a whole is encased in forms, while under the Ransome or " unit " system the columns and beams are cast separately on account of which it is claimed, probably with truth, that the latter method is cheaper.

It is claimed that owing to the rigidity machines can run faster with less vibration than in a mill construction building. This is probably true, but speed is dependent on other things than the rigidity of the building, such as the limitation of the machines themselves, personal skill and accompanying processes. The larger columns necessary are a disadvantage and in textile mills are intolerable. Sometimes steel columns encased in cement are used.

Concrete floors always are a source of trouble on account of wearing unevenly, especially under heavy trucking. Coarse crushed granite in a rather dry cement has been unsuccessfully tried, and the various compositions for preventing wear are so expensive as to necessitate their being used sparingly.

A disadvantage in concrete buildings not occurring in mill construction is the necessity of working out in advance many things in connection with placing machinery, wires, pipes, etc., as well as the difficulty of correction afterward. On the other hand, if planned for, many sockets, inserts and angles for hangers can be placed during construction.

The dusting of floors is a difficulty especially where the dust affects the product. A wood floor is therefore often required and this is preferred as well by operators because the concrete is cold. The best way to lay a wood floor is to place thick planks kyanized or otherwise treated to prevent rot, with the top floor nailed to the planks. This produces a floor of the necessary stability.

The exterior can be treated to obliterate the form marks in different ways by tooling with a pneumatic tool, or washing with a marble, cement or other wash. There is no limit to the ornamentation and beauty that can be given.

Sprinklers are needed as the contents are inflammable. In one case the furniture made a fire that cracked the cement off the reinforcement. The Salem fire showed the importance of abandoning overhang roofs, wood window frames and sashes. In this fire, however, the brickwork offered effective resistance, and with the building walls extended above the roof a mill construction building with metal frames and sash with wired glass will usually withstand an external fire.

The difficulty of demolishing a building tied together in all directions with steel rods encased in material that has become as hard as rock is interesting to consider. As to cost, while it has often been stated that reinforced concrete can be built as cheaply as mill construction, the writer's experience is that the former costs fully 20 per cent more.

It is common practice to fill in the panels with brick, because it is cheaper and looks better. The latter is a matter of taste, the former is questionable, and in Germany, where reinforced concrete has been carefully investigated, such construction has not been found advisable.

Where fireproof construction is paramount and where heavy floor loads are to be sustained, reinforced concrete buildings are desirable; but if these requirements do not exist and the location is isolated, it is hard to justify the additional expenditure.

In presenting the paper the author said that in the Salem fire the behavior of the Naumkeag mill buildings had opened the eyes of engineers because these buildings took fire in consequence of their overhanging wooden roofs and wood window frames, but more especially because one old brick warehouse where the roof was completely protected by a brick parapet stood the fire as well as certain concrete warehouses.

### DISCUSSION

Geo. C. Stone contributed a written discussion in which he said the author had a seeming prejudice against the use of reinforced concrete for factory buildings and insisted that with a fair comparison of advantages and especially of wide bay construction, which is readily obtained in concrete buildings but which is quite an item of expense in mill construction, in that it requires steel beams, the cost of the two types is nearly equal or even in favor of reinforced

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Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

concrete. Besides, reinforced-concrete construction is fireproof. He amplified the good features of reinforced concrete (over mill construction) mentioned by the author, in the following respects:

The floors of concrete are in themselves sufficiently waterproof to prevent water passing through into the story below. Larger window area can be obtained even up to 85 per cent of the gross wall area.

An initial expenditure of $^2/_3$ of one cent per sq. ft. of ceiling area will provide for a liberal placing of inserts which will make the building perfectly elastic for the entire rearrangement of any ordinary kind of overhead machinery.

Additional floor surfaces are mentioned, i.e., plain troweled cement, wood top floor on screeds in cinder cement, wood block on end, terrazzo, linoleum and tile, each with its advantages peculiar to itself.

Regarding architectural effects, it is suggested that more attention could be given to the jointing between the separate pourings, treating these from a design point of view and getting away from the habit of considering the building as a monolith instead of a series of gigantic blocks of artificial stone laid one upon the other and doweled or otherwise fastened together, as it really is. There is no limit to the ornamentation and beauty that can be given, this being dependent only on what is justified for that purpose.

Regarding the fireproof features, attention is called to one of the Naumkeag storehouses in Salem which is of reinforced concrete construction with wired glass windows and was not mentioned by the author. This came through the fire with its glass windows buckled but with its frame uninjured and its inflammable contents unharmed.

J. P. H. Perry presented a written discussion in which he said he thought the author to be unfair to the recognized merits of properly designed and executed reinforced concrete construction for industrial purposes. In view of the tremendous fire loss in this country, it seems unwarranted to recommend non-fireproof or slow-burning construction whenever the owner can possibly afford a fireproof building, especially in view of the difficulty of securing high-class timber and the difficulties with dry-rot.

A number of plants, notably printing houses, have obtained greater efficiency from reinforced-concrete buildings because of, first, their less vibration, and second, the fact that shafting remains permanently true. Upkeep has also been less.

Steel columns have been used in only a small percentage of buildings. The octo-spiral columns of the Hoadley type avoid the waste space occupied by square columns and are better in appearance.

It is too severe to claim that concrete floors "cannot be uniformly dense or hard and that they wear unevenly." The many millions of feet of such floors giving reasonable satisfaction is an answer to this. Some bad floor work is, of course, done and good floors are damaged by severe trucking. Floor hardening materials help, but wax driven into the floors does very little to improve the quality of first-class jobs.

In practice, the difficulty of attaching shafting is very small. At a small added expense, extra sockets of many different forms, now well commercialized, can be frequently located to provide fastenings when changes are required. An electrically driven portable drill has proved efficacious in tapping holes in the concrete in any part at small expense.

Contrary to the author's statement, the majority of chocolate factories in the country are using reinforced concrete with complete satisfaction.

Rarely are board marks removed, but it can be done without a considerable expense by tooling, or the exterior can be stuccoed or veneered with brick or tile. The general appearance depends mainly on the proportions of the structure and the simplicity of the ornamentation plus some wash or paint treatment to bring the exterior to a uniform color. A critic's opinion will be favorable if he will consider the concrete as concrete, not as brick or other material.

Brick curtain walls are often introduced to get what some consider a more pleasing effect. Sand blasting has not usually proven satisfactory because it tends to pick out the soft spots. A cold chisel worked by hand is better.

The author overlooks the four-story reinforced concrete warehouse of the Naumkeag Mills in Salem which withstood the fire without an interior sprinkler going off. The storehouse he refers to was formerly a gasometer without widows and with a newly laid asbestos roof, but with a wood skylight at the peak. The warehouse was undamaged, due probably to a recognized phenomenon, viz., the collection of cold air in spots. All the other mill constructed buildings of the Naumkeag Mills which were recognized by the Mutual Insurance Companies as one of their best risks were destroyed, many brick walls collapsing.

There have been many instances of a fire in a mill construction building where the sprinkler equipment has been cut in two by the early blaze and the rest of the plant entirely destroyed as a result.

Removing concrete buildings has, contrary to the author, been worked out economically and efficiently.

Many competitions in the metropolitan territory have shown an increase over mill construction of 8 per cent to 15 per cent, but if the same floor loads and column spacing are allowed, the cost would be about equal.

The question of adhesion of concrete to bars has been thoroughly demonstrated. With deformed bars at least the stresses assumed in design will be distributed and obtained in actual work. A laboratory test proved that if a commercial smooth bar was milled smooth the bond was materially reduced.

Walter F. Ballinger took exception to using the circular storehouse of the Naumkeag Mills as a sample of the fire-resisting qualities of mill construction. Regarding comparative costs, there have been instances where the difference in proposals has been as low as six cents per sq. ft. between an entire reinforced-concrete building and one of the slow burning or mill construction; in certain circumstances where supply of material is at hand and where railroad sidings exist reinforced concrete is less expensive. In the majority of cases, insurance and upkeep considered, reinforced concrete is usually more economical.

Reinforced concrete permits a small number of posts and greater spans and with the use of the spinal type of column, it need be no larger than yellow pine. It is practicable to build a span as long as 60 ft. This has been done at an actual saving over steel fire-proofed, and in one case was even cheaper than having the steel structure unprotected.

It is known that machinery will vibrate less in a reinforced-concrete building, and this has actually resulted in saving of electric current due to the machinery running more true.

Walter S. Timmis: Further objections to mill construction are, the difficulty of getting timbers for long spans properly seasoned, the time it takes to get timbers, and the shrinkage of beams away from the girders and the large amount of vibration. Except in buildings over eight stories, sizes of columns need be no larger than required by cities of the first class for steel columns fireproofed. The machinery layout and provision for changes merely resolves itself to putting into the concrete sufficient inexpensive inserts. Lay the plant out first and build the building around it. Most everyone believes in sprinklers in any type of construction.

The Author said in closing that one object in writing the paper was to create discussion and that he was appreciative of the contributions which so well accomplished this.

## MEASURING EFFICIENCY

BY H. L. GANTT, NEW YORK CITY

Member of the Society

The author contends that the attempt of the accountant to furnish the financier with easily obtainable measures of efficiency has not only been a failure, but that the attempt to use as measures of efficiency the criteria which he has provided, is one of the most serious causes of inefficiency with which the practical manager has to contend.

Fortunately for industry at large, the first fallacy, namely that it is necessary to have low wages in order to get low costs, is rapidly falling into disrepute; but the second, namely, that the ratio of non-productive to productive labor is a measure of efficiency, is still strongly and almost universally held by accountants and financiers. This fallacy, on account of its widespread acceptance, is responsible for more inefficiency than almost any other cause.

Inasmuch as the object of increasing the efficiency of an industrial operation is to reduce the cost of that operation, the only real measure of the efficiency with which the operation has been performed is found *in the effect on its cost.*

The only reliable indication, then, of the efficiency of a plant is furnished by the detail shop cost of the operations performed.

Before any great progress in the solution of our industrial problems can be made, the two fallacies referred to must be abandoned, for they not only directly hamper the operating executive in his efforts to promote efficiency, but impose upon him conditions that make it almost impossible for him to secure the proper coöperation of his employees, and are thus indirectly the cause of much of our industrial unrest. In reference to these two fallacies the author says:

With the growth of competition within the last 20 years the necessity for some knowledge of costs became evident, and the manufacturer turned to the accountant for a system of finding costs.

The present system of railroad accounting had been developed, and certain ratios accepted as measures of efficiency of operation; notably among them the ratio of operating expense to total income.

Being accustomed to having the managerial efficiency of railroads expressed by a simple ratio, the financier demanded a similar simple measure of the efficiency for an industrial plant. The cost accountant promptly gave him what he called the ratio of "non-productive" to "productive" labor, which he said should be low for good management. By "non-productive" labor he meant salaries of all kinds, and all other labor that could not be charged directly to an order, including miscellaneous labor such as watchmen, sweepers, truckmen, etc. By "productive" labor was meant simply that labor which could be charged directly to an order.

While the ratio of operating expense to total income may be a fair measure of efficiency in a transportation company, the ratio of "non-productive" to "productive" labor is not only not a fair measure of the efficiency of operation in a manufacturing plant, but is often exactly the reverse.

To my mind the widespread use of this ratio as a measure of efficiency, has been more effective in producing inefficiency than any other single factor, except the oft-repeated statement that you must have low wages if you would have low costs. Until these two fallacies are absolutely discredited, we cannot expect a solution of our most serious problems.

Of these two fallacies, the second, namely, that you cannot have high wages and low costs, seems to be yielding gradually to the overwhelming mass of evidence against it. So many cases are now on record where the industrial engineer has increased output, raised wages, and at the same time lowered costs, that only those who are too conservative to investigate are still holding on to the old theory. Better still, many employers have shown the courage of their convictions by adopting a scheme of management for the increase of output and the reduction of costs, which they are perfectly well aware will make a decided increase in wages. With evidence of this kind at hand, it is safe to say that this fallacy will before long be entirely discredited. On the other hand it must be fully understood that something more than a simple increase in wages is necessary to increase output, and if nothing is done but to increase wages we are sure to get higher costs.

The other fallacy, that the ratio of "non-productive" to "productive" labor is a gage of efficiency, is so firmly rooted, however, that it is hardly to be expected that it will yield in the near future.

In speaking of cost systems the author states that the essential elements of a reliable system are a knowledge each day of

*a* what was done the day before
*b* who did it, and
*c* what was paid for it

It is comparatively easy to get a set of returns purporting to give this information, but the real difficulty comes in knowing whether these returns are correct or

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not. The only sure way of judging of the correctness of these returns is to know beforehand

*a* what should be done the next day
*b* who should do it, and
*c* what should be paid for it

If work can be planned on these lines the basis is formed for a real system of management. In fact, he says:

Even in the most poorly run business, some attempt, either consciously or unconsciously, is made to control work on these lines. Moreover, we generally find that the more nearly the above ideal is approached, the most successful the plant is, and all will admit the desirability of such a system if it can be established without excessive clerical work.

When it is realized that the installation of such a system seldom results in an increase of output of less than 25 per cent, and often as much as 100 per cent, it is easy to see that the additional clerical work cuts but little figure. As a matter of fact *the clerical work needed to operate the best systems of this type is decidedly less than that needed to operate any of the standard cost systems put in by chartered accountants.*

It must be borne in mind, however, that during the process of installing the new system and training the employees to operate under it, the old system must be continued; and not until each function performed by the old has been taken over by the new can we drop the old entirely.

During the process of installation, therefore, we must to a large extent operate two systems. This necessarily runs up the ratio of "non-productive" to "productive" expenses, and the accountant lifts up his hands in horror at the expense the new system is running them into. If at the same time the new system is successful in reducing the "productive" labor, the ratio is still higher, and the "showing" is still worse, even though the total cost is less. I therefore repeat that the first step to be taken before introducing a modern system of management is to eliminate the ratio of "non-productive" to "productive" labor as a measure of efficiency.

The elimination of this ratio as a measure, and the establishment of the fact that total cost is the only reliable guide, will do much to pave the way for an improved system of management. How is this to be accomplished?

The first step is to revise our ideas as to the functions of a cost system. In the past the principal function of a cost system, besides indicating a limiting selling price, has been to enable those in financial control to criticize those operating the factory. These criticisms are usually from one to three months late, and are so general in their character as to afford, as a rule, no guide whatever by which the superintendent can be governed. Such a system is too often most highly prized for its worst defect, namely, that it enables those in financial authority to criticize without taking any responsibility whatever for showing how to do better.

If, instead of making the function just described the prime one, we raise to equality with it, a function which requires the system to furnish promptly, day by day if necessary, exact information of what has been done and what the expenditure has been, we shall find that its most valuable function becomes, not finding costs, but furnishing the superintendent with information which helps him to reduce costs.

In other words, before we can expect to get any great benefits from the newer managerial ideas, we must readjust our ideas of the functions of the cost accountant, *who must become the servant of the operating executive as well as of the financial executive.*

As long as the cost accountant is simply a critic, he may be called "non-productive," but when he furnishes the superintendent with prompt information which enables him to reduce costs he becomes "productive." Prompt detail information of what is being done each day, furnished in such manner as to be readily compared with what has been done, and what can be done, is the best method of measuring efficiency.

## DISCUSSION

Harry E. Harris contended that the annual monetary return for the amount invested is what interests those responsible for any undertaking. This cannot be measured by any arbitrary rule of accounting, nor by a comparison of the earnings of the wage earner. Neither can it be judged by individual costs of separate operations without consideration of overhead factors, since it is possible to show by cost records a very high increase of efficiency and still operate under an increasing loss. Efficiency, taken in the sense of manufacturing at a low direct labor cost, is not always synonymous with economy, and therefore is not always expedient.

Rather than depend upon day-to-day costs, which, while valuable to a certain extent, are expensive to maintain, the writer preferred that efficiency should be measured periodically, by taking the total productive costs, *i. e.*, direct and indirect labor, plus salary expense, material, a portion of the cost of new equipment, etc., together with the total sales value of the articles produced during some period, and comparing their ratio with similar ratios taken at previous periods.

Fred J. Miller said that the percentage of operating expense is of no importance by itself; a low percentage may mean a high total cost of product, or a high percentage a low cost of product. In a factory where the work is done mostly by hand, with low cost fixtures or tools, labor costs will be high, and operating expense or overhead charges low. Suppose, however, that automatic machines are devised for doing this work, and that almost no human agency is required for their operation. Under such conditions the percentage of operating expense might rise from, say, 20 to 1000 per cent, if based upon labor cost, yet under the second condition the total cost presumably would be lower. It cannot be too often insisted upon that the term "non-productive labor" is a misnomer; that there is no such thing as non-productive labor in a well-organized and well-managed industrial establishment. The work of clerks, draftsmen, pattern makers, tool makers, etc., is usually productive labor in the highest sense.

H. K. Hathaway said in elaboration of certain details referred to by Mr. Gantt that under scientific management, not only is the ratio between direct and indirect labor increased as a result of lowering the amount of direct labor through the elimination of wasted effort, but by transferring to others many of the things which the workman formerly

did himself, as, for example, the grinding of tools, fixing belts, planning the work, etc. This work is just as productive as if done by each machinist himself, although it is difficult to charge it directly to the various jobs to which it applies. Those who attach such great importance to the ratio of indirect to direct expense should consider that the more inefficiently those whom they class as producers do their work, the lower will be their ratio. The only satisfactory means for measuring efficiency is a comparison of work done with a task set, based on standardized conditions and accurate time study.

Henry H. Suplee thought that in determining efficiency it was frequently done from the wrong end, that is, after operations were conducted, instead of with some reasonable degree of truth beforehand. He commended the principle involved in the simple methods of the man who manufactured clothing in New York. He made what he called "pants," and his method of reasoning was as follows: "I can sell these for $2.50 a pair. If I cannot sell them for that, I cannot sell them at all. I must make 50 cents profit on each garment, or I do not want to make them at all." He took out his profit first. That left $2 a pair for manufacture. Then he figured how many pairs an operator could make in a day, and how much wages he would have to pay the operator at the union rate. He figured his overhead charges, rent, clerk hire, etc., and after deducting all his expenses of this character, determined how much he had left to buy the materials, and the quality of the materials he purchased was covered by the amount at his disposal.

W. A. Polakov said that the quintessence of the shortest paper presented at that session, but on the biggest question, is the statement that the most valuable function of the management is not finding costs, but furnishing the superintendent with information which helps him to reduce costs. Information furnished by accountants is like that which tells us why a patient has died. What is needed is a diagnosis from which the management can learn before everything is over, what, when and how the work shall be done, and therefore how much it will cost.

It had been the good fortune of the speaker to work for and with the author, and as he was now applying the principles of Mr. Gantt to his own business of managing central stations, he had invariably found that an unprecedented increase of efficiency and reduction of costs is possible, if the operating force is supplemented by a body of "non-producers" constituting a planning department, whose office is to teach the producers what, when and how to do.

## STANDARDIZATION IN THE FACTORY

BY CARL BENNETT AUEL, EAST PITTSBURG, PA.

Member of the Society

A brief outline is given in this paper of the ways and means employed by a large electrical establishment in their work of standardization.

*Drawings:* It was formerly the custom to make all drawings as complete and self-contained as possible. Opposite each item a note was placed specifying the material required to manufacture it. When drawings for new apparatus were made and any of the old parts could be used, these parts were shown again on the new drawings in complete detail, so that the workmen would not have to refer to any other drawing. This method was found to involve more and more a duplication of drafting and clerical work and the scheme of making elemental drawings with one piece on a drawing was next considered; but, while this insured accuracy in duplication, it had the disadvantage of too many drawings to handle. A compromise arrangement was therefore adopted, consisting of a natural grouping of pieces or parts on a single drawing. Each piece is assigned an item number and a list of the material involved is located conveniently on the drawing arranged numerically according to item numbers as shown in Fig. 1.

Fig. 2 shows a standard drawing of a line of wing nuts, arranged, however, in such manner that the various items may be cut into cards and issued to workmen who can attach them to the belt shifters of their machines when working.

*Manufacturing Information:* All apparatus and parts are built to so-called manufacturing information, which consists of a specification setting forth the drawings to be worked to, with a list of the various kinds and amounts of material required. Copies of such portions of these specifications and drawings as pertain are issued to all departments having work to do in connection with an order, and these specifications are closed when the order is completed.

*Specifications and Shop Processes:* When either the quality or the importance of the items warrant, specifications are carefully prepared for the purchasing and the inspection departments who use them in the purchase and the subsequent inspection of such materials. Another equally important line of work consists in the development of manufacturing processes and formulæ which, when standardized, are recorded in permanent form and issued to the various manufacturing departments involved. In this way uniformity in product is assured, there is no needless repetition of lessons or experiences previously learned, and the company is made independent of any individual's knowledge.

In the paper is reproduced a set of specifications for cold-drawn steel, the general arrangement of which is in accordance with the standards of the American Society for Testing Materials. An example is also shown of process specifications.

*Visible Production Charts:* In Fig. 3 is shown a form of production chart, or load diagram, used quite generally throughout the works. Curve *a* is the daily total of unfilled orders, machines or pieces obtained by adding to the total on hand, the number received each day and subtracting the number shipped. Curve *b* shows the maximum possible out-

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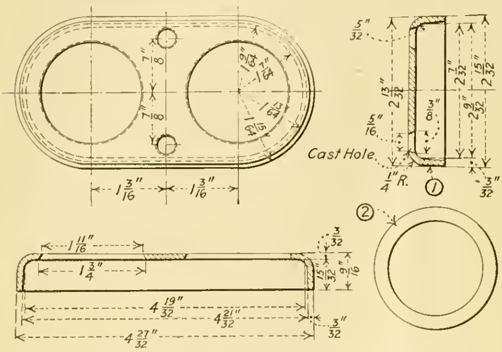
put of which the department is capable in a month. Curve $c$ is the desired output for the same period. While these two latter are both straight lines, their




| Drawing No. 181577 | BILL OF MATERIAL | | Sub. No. 1 | | |
|---|---|---|---|---|---|
| Item | Description and Material | Pat No. | Req. | Dwg. No. | Tool No. |
| 1 | Flange C. I. S-No. 99665 | U-8266 | 1 | | |
| 2 | Felt Washer S-No. 42053 | | 2 | | |
| | | | | | |

Fig. 1 Mercury Rectifier Outfit. Double Flange for Transformer Porcelain Bushing

shape could of course, be altered, though with a loss in simplicity. Curve $d$ indicates the actual output and a comparison between it and curve $c$ tells whether the department is working up to its schedule or falling behind. Curve $e$ is that of actual daily deliveries.

*Standardization:* Owing to the obvious need for having certain standard sizes and kinds of materials, the first steps in standardization naturally fell to the drafting department. Later a standards division of the engineering departments and a Standards Committee were created, whose functions are the standardization of existing materials and parts. The work of the Standards Committee has been varied in the extreme, such matters having been successfully handled as punched circular washers, thumb and wing nuts, oil-hole covers and hinges, furniture, anchor holes in bearings, wood handles, sizes of tap drills, stresses in eye-bolts, thickness of babbitt in bearings, liners, trucks, etc.

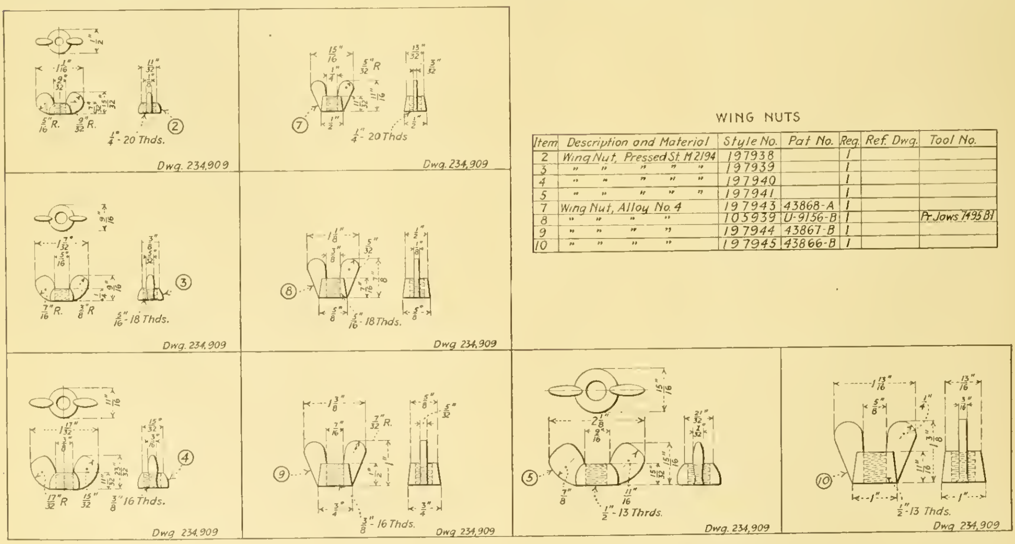
Cutting tools have been standardized as well as die and jig parts, die shoes, punches and punch holders, punch and stripper plates, jig boxes and bushings, drill press shanks, etc. Endeavor has been made to place on working drawings the allowable variations from drawing dimensions for standard parts.

The method which has been adopted consists in placing the nominal dimensions first, followed by the limiting dimensions in brackets: thus $4\tfrac{1}{4}'' \left\{ \begin{array}{l} 4.251'' \\ 4.248'' \end{array} \right\}$. There has, however, been a certain preference expressed for a slightly different method, namely

$$4\tfrac{1}{4}'' \left\{ \begin{array}{l} '' + 0.001 \\ '' - 0.002 \end{array} \right\},$$

but the objection to this method is that whoever uses these dimensions must add or subtract the allowance each time same are used.

*Allowances for Expense Materials:* The monthly




| Item | Description and Material | Style No. | Pat No. | Req. | Ref. Dwg. | Tool No. |
|---|---|---|---|---|---|---|
| 2 | Wing Nut, Pressed St. M 2194 | 197938 | | 1 | | |
| 3 | " " " " " | 197939 | | 1 | | |
| 4 | " " " " " | 197940 | | 1 | | |
| 5 | " " " " " | 197941 | | 1 | | |
| 7 | Wing Nut, Alloy No. 4 | 197943 | 43868-A | 1 | | |
| 8 | " " " " | 105939 | U-9156-B | 1 | | Pr Jaws 7495 B1 |
| 9 | " " " " | 197944 | 43867-B | 1 | | |
| 10 | " " " " | 197945 | 43866-B | 1 | | |

Fig. 2 Section of Standard Drawing of a Line of Wing Nuts

consumption of various expense materials, such as oils, greases, waste, incandescent lamps, janitor's supplies, etc., has been estimated for the individual manufacturing departments, based on normal production. From these investigations, allowances have been set on each item and a department is permitted to draw from the storehouse on requisitions up to its allowance. Anything in excess must first receive the approval of the superintendent of the department.

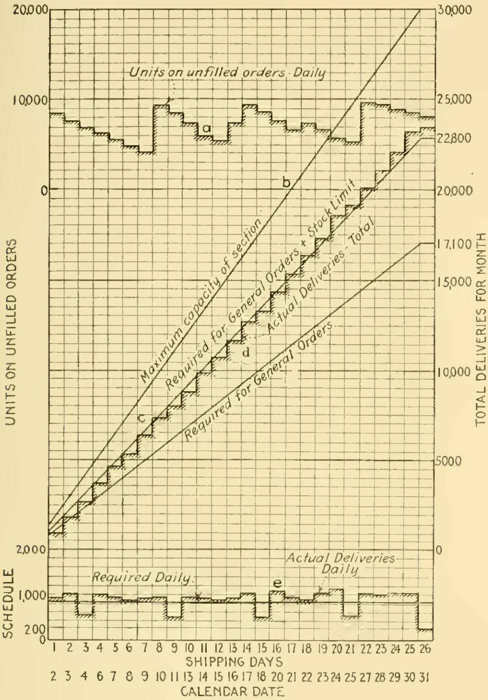



FIG. 3 LOAD DIAGRAM

*Handling Materials:* Considerable study has developed economical means for handling smaller materials, as for example misprint cloth bags in place of paper wrappings; for larger material metal tote boxes without wheels or with telescoping wheels. For transporting, standard gage steam and narrow gage electric storage battery cars and hand, platform lifting and electric storage trucks are used. These latter have proved very profitable as labor savers. A central oil storage warehouse has been established with pipe lines to each building. A further development will be the delivery within the building of oil from an electric truck, and this method could be worked out advantageously for inter-department delivery of material. Mail is handled from a central post-office through pneumatic tubes to the principal departments.

*Safety Methods:* Well-defined steps have been taken for the systematic introduction of safety methods and devices. A supervisor of safety appliances was appointed and a monthly appropriation issued to cover the cost. No new tools are erected nor old tools replaced without adequate safeguards, by which means dangerous tools or equipment are gradually eliminated. An analysis of the accidents for the past year shows but three-tenths of 1 per cent to have been caused by the absence of safeguards. By far the largest percentage, namely, 21½ per cent, were due to the carelessness of the injured themselves, so it means a campaign of education must be undertaken. This is being accomplished in several ways as for example, through the medium of small yet prominent Safety First metal plates which have been placed in a prominent position on every machine. Signs bearing this and similar legends have been recently standardized by several national societies, among them Founders, Manufacturers, Metal Trades, and Electric Light. Lectures are also given to workmen which are repeated to the same persons at intervals of six months.

*Inactive Materials:* All stock ledgers are regularly scrutinized by the storekeeping department and slow-moving or inactive items submitted to a materials disposition department that investigates not only the cause of the inactivity with a view to preventing a recurrence, but at the same time endeavors to dispose of the material to the best advantage.

## DISCUSSION

H. B. LANGE said in a contributed discussion that to appreciate the field of opportunity for standardization it is to be noted that many works organizations maintain engineers who make this work their sole function. It has been often demonstrated that on repetitive work low costs can be accomplished by reducing all product to a unit basis without reference to the final assembly. Where working within limits of allowable variations it would seem advisable to draw one part only on a subdivision of a drawing sheet preferably of letter sheet size—with a separate part list and an arrangement drawing giving the assembly information. Proper filing and classification of prints of drawings assists in selection of parts already in use and revealing parts of similar character which might be consolidated for standard adaptation. The cost of drawings is negligible compared with accrued benefits. Mounting prints on strawboard and keeping them filed when not in use is economy. Standardization can be furthered by a showing on a letter size sheet the part with a list below of the differing dimensions. This is especially applicable to purchased parts used, and these bound together give a simple and condensed means of imparting essential information. In fact this same size sheet and the letter dimension scheme extended to parts made in the shop is worthy of consideration.

L. D. BURLINGAME said the paper illustrates the transition from the old-time method when the man in charge knew every part and could adjust all parts to make a completed

unit to the new method of making parts from a carefully prepared drawing with sufficient information thereon so that when assembled the final unit will come together satisfactorily. It brings out, further, the present time method of manufacturing parts in large quantities at one time and having them available when needed.

The matter discussed in the paper of how to show dimensions on drawings should be determined by adopting whichever way produces the best result depending on the class of employees but the gage system marked in decimals should be used in figuring drawings.

## OPERATION OF GRINDING WHEELS IN MACHINE GRINDING

BY GEORGE I. ALDEN, WORCESTER, MASS.

Member of the Society

Long experience in the use of grinding wheels has developed facts in regard to their action, which, however, have been stated only as empirical rules. Such rules are easily forgotten or confused by operators because they are not related in any obvious way to any known principles by which results may be predicted. For example, what is the effect upon a wheel of increasing the speed of work, or of increasing the diameter of the work, or of diminishing the diameter of the wheel?

This paper gives an analysis of the action of the wheel when in operation. It shows the distinction between the radial or real depth at which the wheel cuts and the depth which the abrasive grain in the wheel cuts into the material being ground. This latter depth is termed the "grain depth of cut," which is the *controlling factor* in securing the correct working of the wheel. This grain depth of cut is indicated in Fig. 1, where

$C$ = the center of the wheel
$c$ = the center of the work
$OP$ = the radial depth of cut
$OQ$ = the arc of contact of wheel and work.

Owing to the revolution of the wheel and work, a cutting point $O$ on the wheel will move to $Q$ in a certain time and a point $Q$ on the work will move toward $P$ to some point as $W$. The chip removed is represented by $OQW$ and the *grain depth of cut* is $WS$.

When a grinding wheel is working properly, the abrasive grain of the wheel may be considered as cutting small chips from the work, and the surface of the work as cutting or wearing away the bond of the wheel. It is quite evident that the greater the grain depth of cut, the more effective will be the action of the work upon the bond of the wheel. So long as the bond is being worn away just as fast as the abrasive grains of the wheel are being worn down, the wheel will continue to work well. If the bond is cut away too rapidly, the wheel will appear too soft, and will wear away too rapidly. If the cutting grains wear down faster than the bond is cut or worn away, the face of the wheel will become glossy, and the wheel will not cut freely. These considerations lead directly to the conclusion that the action of a given wheel on a given kind of work is almost entirely dependent upon the grain depth of cut. If the grain depth is too great, the wheel wears away too rapidly. If the grain depth is too small, the wheel may glaze.

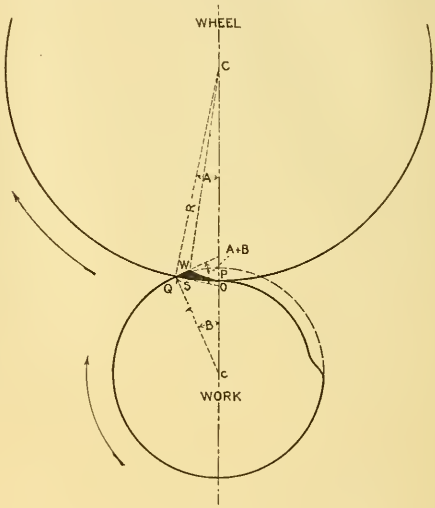



FIG. 1

It is therefore important to know how the grain depth of cut may be regulated.

As is evident from Fig. 1, one relation that affects the grain depth of cut is the ratio of the work speed to wheel speed, represented by $QW$ and $OQ$. It is also affected by changes in diameter of wheel or work. Assuming

*a* Other factors remaining constant, increase of work speed increases grain depth of cut, and makes a wheel appear softer

*b* Similarly, a decrease of wheel speed increases grain depth of cut

*c* Similarly, diminishing the diameter of the grinding wheel increases grain depth of cut, and increasing the diameter of the wheel decreases grain depth of cut

*d* Similarly, making the diameter of work smaller increases grain depth of cut. Conversely, making the diameter of work larger makes grain depth of cut smaller

In applying the principle that grain depth of cut is the main factor, the correct relative speeds of work

Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

and of wheel must be found by trial for each wheel and each kind of work. When this has been done, the principle of grain depth of cut will enable one to know the direction in which to make the changes of work speed or wheel speed, to adapt the wheel to changes in its own diameter, or to other sizes of the same kind of work.

In the foregoing it is assumed that the object of grinding is to remove stock rapidly. Often, however, the character or finish of a ground surface is of primary importance. From the point of view of grain depth of cut, a smooth surface by grinding would be obtained if the grain depth of cut were very small, and therefore the work speed should be relatively slower for finishing than for roughing. That the bond may be worn away by a very small grain depth of cut, a softer wheel would be used for fine finishing than for roughing. A very hard glazed wheel may sometimes produce a mirror-like surface on the work; the action in this case being a sort of burnishing process.

The following formula expresses the grain depth of cut:

$$d = \frac{v}{Vn} \sin (A + B)$$

where

$v$ = surface velocity of work
$V$ = surface velocity of wheel
$n$ = number of cutting particles per unit length of circumference of wheel.

In the paper a table is given of arcs of contact for different diameters of wheel and work, and examples are worked out to show the change in grain depth of cut due to changes in radial depth. These show that increase of radial depth does not increase grain depth in the same proportion. In one case, doubling the radial depth increased grain depth only 40 per cent. If, however, sin $(A + B)$ is increased, say 40 per cent by doubling the radial depth, the formula shows that $v/V$ might be diminished by about 30 per cent without changing the grain depth; but these changes, which have not varied the theoretical value of grain depth $d$ have increased the rate of production 40 per cent. This indicates that production may be increased without increasing grain depth of cut, by increasing the radial depth of cut, and at the same time diminishing the work speed a less per cent than the radial depth is increased. In practice this method of increasing production requires rigidity of machine and work.

## DISCUSSION

C. H. Norton said that he wondered whether those interested had got the thought which the author offered. It has to do in the operation of grinding machines with the selection of the speed of the work for a given radial depth of cut. The paper indicates that the production may be increased by slowing the working speed and increasing the radial depth, without destroying the wheel as rapidly as if it were attempted to cut to a greater depth or with a rapid revolution of the work.

The Author, in answer to an inquiry by M. D. Hersey as to the effect of pressure of the wheel against the work, said, that for a given radial depth of cut, the pressure depends on the condition of the wheel. If the wheel cuts badly the pressure is heavy and vice versa. The faster the work is worn down the faster it wears away the bond, the friction between the work and wheel is large and pressure becomes greater.

In response to further inquiry as to the importance of the rigidity of support of the grinding wheel and its rigidity in the bearings, it was brought out that the life of the wheel and the amount of effective work and the rapidity with which it produced are dependent upon rigidity. Mr. Norton said that he used very carefully made bearings and that they were fitted to a degree of nicety where the ordinary engineer would condemn them because they ran hot. A thin lubricant is used and good results are secured.

# FRICTION LOSSES IN THE UNIVERSAL JOINT

By P. F. Walker, Lawrence, Kans.
Member of the Society
and W. J. Malcolmson, Lawrence, Kans.
Non-Member

During the past three years two standard makes of universal joints have been under observation and test in the laboratory of the Mechanical Engineering Department of the University of Kansas, with the object of determining the loss of power due to friction in the joint while operating under such loads and speeds as are common in automobile service. In each case two complete joints connected by an intermediate shaft were employed, so that in service during the tests power was transmitted through the set from the primary shaft to a parallel secondary shaft, Fig. 1. All observed data relate therefore to the loss occurring in two joints. The main dimensions were as follows:

| | Joint No. 1 | Joint No. 2 |
|---|---|---|
| Diameter intermediate shaft..... | $1\frac{1}{2}$ in. | $1\frac{3}{4}$ in. |
| Length of shaft................ | 22 in. | 13 in. |
| Dimensions of each bearing..... | $\frac{3}{4} \times \frac{3}{4}$ in. | $1\frac{5}{16} \times 1\frac{7}{16}$ in. |
| Maximum angle of deflection.... | 15 deg. | 14 deg. |
| Horsepower rating.............. | 16 h.p. | 30 h.p. |
| Lubricant used................. | hard grease in each | |

The kinetic relationships embodied in the universal joint is such that the driving and driven shafts must be parallel in order to secure a uniform velocity ratio. If the second shaft makes an angle with the first, it will have a variable velocity, the extent of which will depend upon the size of the angle.

Further, in assembling the joints, the forks on the

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Abstract of paper presented at Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to non-members.

intermediate shaft should be in the same plane. This point is not appreciated by the average person using universal joints, about half the joints being wrongly assembled with the forks on the intermediate shaft at 90 deg. or some other angle to each other. This gives rise to unsatisfactory operation and the joints of the machine are often indiscriminately condemned.

The actual determination of the friction losses in

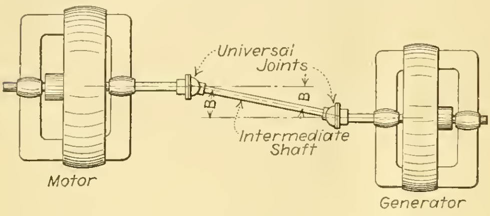


Fig. 1 Arrangement of Machines

universal joints, such as are used in automobile power transmission, under proper conditions of speed and load requires extreme delicacy and care. The difficulty in this problem lies in the fact that the amount

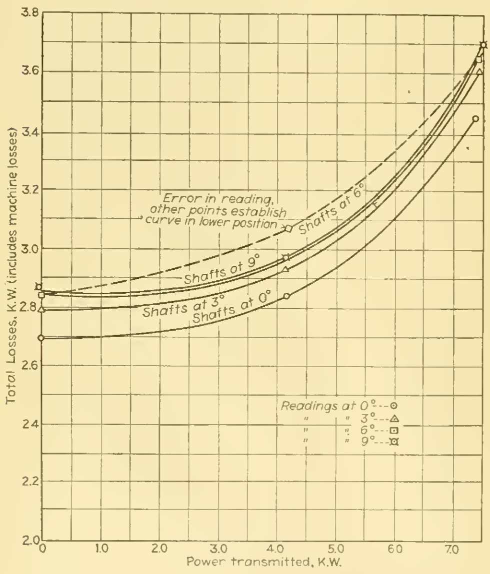


Fig. 2 Joint No. 1. Forks in same Plane, 800 R.p.m.

of power dissipated in the joint, as friction loss, is very small compared with the amount of power transmitted. Practically the only way to measure the loss in the joints is to determine the power delivered to one of the shafts and the power delivered by the other end. The losses would then be the difference between the input and the output. As these two quantities are comparatively large and nearly equal, any small error in their determination would produce a relatively

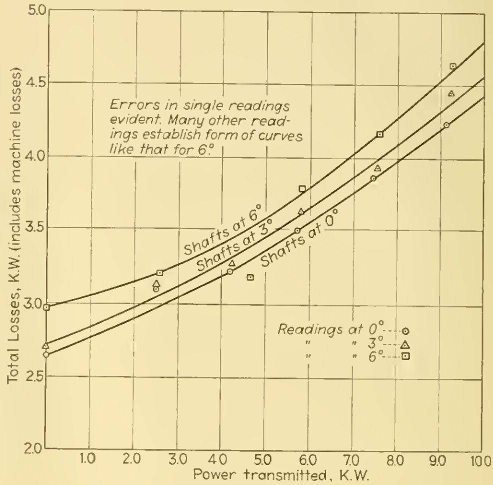


Fig. 3 Joint No. 1. Forks at 90 Deg., 800 R.p.m.

large error in the derived value of the loss. In the actual performance of any experimental work to determine this loss of power in the joints as friction, the problem becomes that of measuring accurately the power supplied to, and that received from the section of shafting which includes the joints.

In considering the several possible methods of meas-

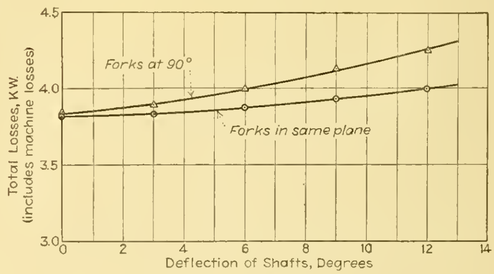


Fig. 4 Joint No. 1. Constant Load, 800 R.p.m.

uring the power transmitted by line shafting the accuracy required to determine the relatively small value of the friction losses in the universal joints put the general class of dynamometers out of the question, and it was early decided that to obtain any accuracy whatever with the facilities and time available, electrical methods should be used throughout and it was decided to use the Puffer Modification of the Kapp Load-Back Method of Testing, as described in Foster's Electrical Engineer's Pocket Book (1908 ed.).

Briefly, in this method of testing two machines, preferably of the same size, make and rating, are both electrically and mechanically interconnected. One machine operates as a motor and drives the other mechanically as a generator. The current generated by the generator is loaded back on the motor supply line. Since one machine takes power as a motor and the other returns power as a generator, the net power taken from the line is only that which is required to supply the total losses of the system.

The actual procedure in carrying out the experiments consisted in first running the machines with all shafts in the same straight line and determining the total losses of the system as a whole. With the main shafts kept parallel, and keeping as nearly constant as possible all other conditions, such as speed, temperature, lubrication, and general conditions, the losses of the system were again determined for a certain angular displacement of the intermediate shaft. Readings were taken at different angular displacements and similar runs were then made for various speeds and loads. Experiments were made for both sets of joints both with the forks on the intermediate shaft at 90 deg. to each other and with the forks in the same plane. Assuming, correctly, that the losses in the joints are zero for conditions of straight line drive, with all other conditions remaining the same, the friction losses for a certain displacement of the intermediate shaft would be found by subtracting from the total losses of the system at that displacement the total losses under conditions of straight-line drive.

With the forks at 90 deg., there was noticeable a distinct vibration and knocking which was not present when the joints were properly assembled. This vibration increased as the angle of deflection increased, sometimes becoming so pronounced for the larger angles that it was found to be unsafe to try to operate.

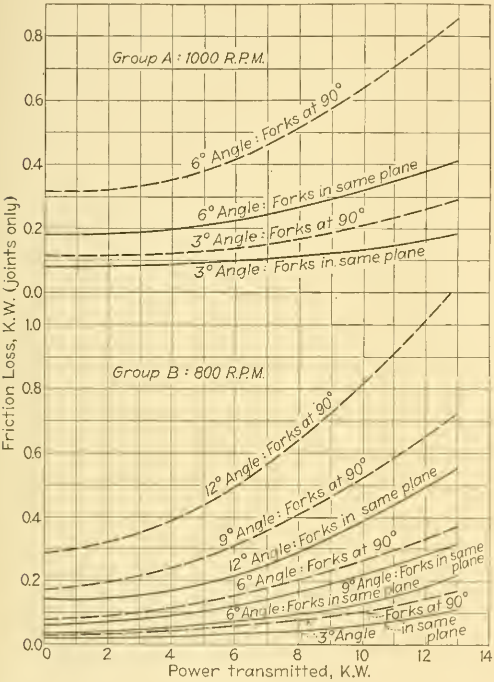


Fig. 5 Friction Loss at Varying Angles. Values Derived from Averages

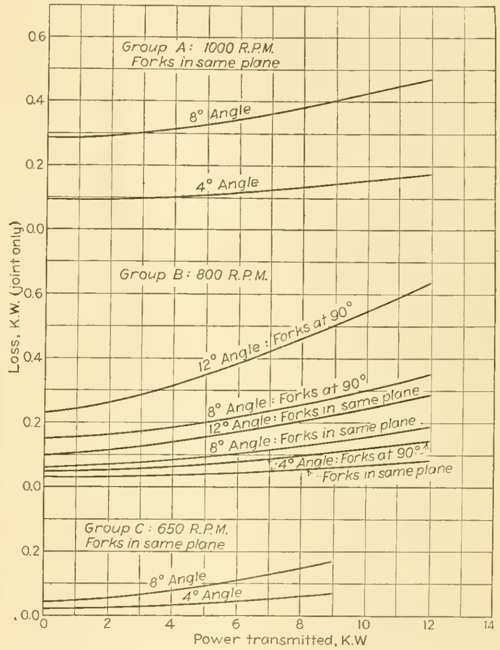


Fig. 6 Joint No. 2. Friction Loss at Varying Angles, Values Determined from Averages

Two general methods for securing readings which should cover variations, both in load and angle of inclination were followed. One consisted in lining the shaft exactly for straight-line drive and under this condition of zero loss operating the joint through a wide range of loads. This being done, the driven machine would be offset to give any desired angle and the apparatus then be operated through exactly the same range of loads, speed being held constant for all conditions.

The other method consists in holding both speed and transmitted load constant during the entire se-

ries of observations. In this case, with the shafts in direct line for straight-line drive, the initial value of total loss corresponding to zero loss in the joint is determined. After this, with the machines still running, the generator would be moved to give the proper offset angle and the readings for that condition taken with but a few moments delay. This would be repeated for as many angles as desired.

Figs. 2, 3 and 4 show curves which represent the individual readings of total losses, and Figs. 5 and 6

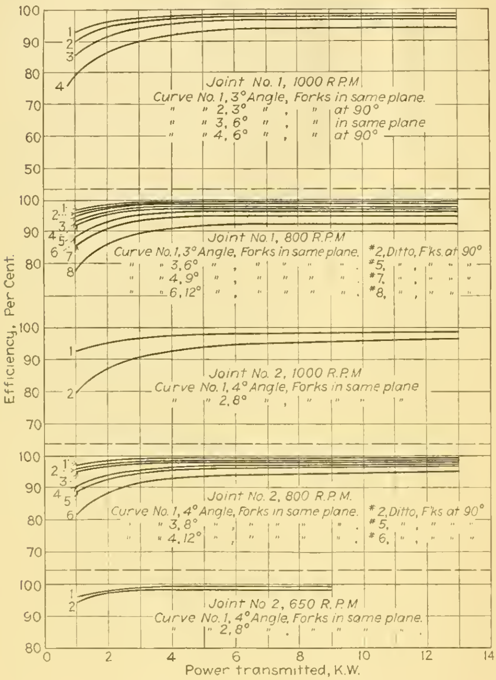


Fig. 7 Efficiency Curves

are curves showing the true friction loss. Fig. 5 pertains to joint No. 1 as operated at the two speeds of 1000 and 800 r.p.m. Fig. 6 gives corresponding information for joint No. 2. They represent the final results of all of the work and are located by points which are fixed by taking averages of many observations. In changing from the basis of total losses to friction loss in the joints alone, the total loss for zero angle was first deducted from all other values of total loss, determined during that particular day's work. All such differences, each representing a loss due to angularity, were then cast onto one common base line and a single representative curve established for each angle investigated. It did not seem necessary to extend the work to secure data for all conditions of load and speed for the joints improperly assembled with the joint forks set at 90 deg. on the intermediate shaft. Enough was done to demonstrate the necessity of assembling properly.

In the calculation of efficiency of the joints it seemed wise to make the conclusions applicable to a complete system including the two joints necessary to secure parallel operation of the main shafts. In case a knowledge of the efficiency of a single joint is desired, it may be assumed without sensible error that the loss is one-half of the amount here recorded and that the efficiency would be indicated for each condition by a fraction which is the arithmetical mean of the figure here given and unity. The difference between the amounts of power transmitted by the two joints is so small as to be outside any possible limits of observation.

The efficiency is calculated directly from the curves of derived values of friction loss. For any power and angle the friction loss in the two joints is read. The power is, in all cases, the amount transmitted at the joint, it being the sum of the load delivered by the driven generator and the losses of that machine. These latter losses have been based on separate tests made to determine the machine characteristics. It follows, therefore, that efficiency equals the power transmitted divided by that power plus the friction loss; that is, it is power delivered divided by power received by the joints.

Fig. 7 shows the efficiencies of the universal joint sets in the various conditions of operation. From these curves it is noted that for loads amounting to one-half the rating of the set, or more, the efficiency is nearly constant and the loss very small for angles of inclination not exceeding 6 deg. For larger angles the loss becomes an appreciable amount. The constancy in the efficiency fraction indicates a constant value of the coefficient of friction on the joint journals, since the bearing pressures are proportional to power transmitted while speed remains constant. Under conditions of service the questions of lubrication and protection from dust are important. In the efficiency calculation a downward tendency was noticeable at the largest loads although it is not visible on the curves. Doubtless it marks the point where the bearing pressures on these journals make lubrication imperfect. The rocking motion of the journals tends to squeeze out the oil.

# RAILROAD SESSION

## REPORT OF SUB-COMMITTEE ON RAILROADS AND CONTRIBUTED DISCUSSION

*At the Railroad Session of the Annual Meeting, Wednesday afternoon, December 2, a report was presented by the Sub-Committee on Railroads on Steam Locomotives of Today, which outlined the principal features of the locomotive problem as it now appears to railway mechanical officials. The subject was topically arranged, and each of the topics was discussed, some of the contributed discussions being exhaustive in character and of more than ordinary interest. The report of the Committee, which was brief, is reproduced in complete form below, while the discussions are presented in abstract form.*

### STEAM LOCOMOTIVES OF TODAY

Recent progress and improvement in the efficiency and capacity of steam locomotives has been of such remarkable character and extent that a record in the proceedings of this Society is justified.

Steam and electric locomotives as rivals in the same field has been a favorite subject for discussion before engineering societies, and it is easy to start arguments in favor of each of these rivals among the partisans interested. Whether or not the steam locomotive is to be displaced by the electric is, of course, an important question which will in time be settled by the court that settles all such questions, that of the treasurer's figures. For the present and for the immediate future the burden of transportation falls and will continue to fall upon the steam locomotive. If the steam locomotive is to be perpetuated it is fitting that it should be improved to the utmost limit. If it is to be finally displaced it is fitting that it shall be so improved in order that progress to something better shall be intelligently developed upon a solid foundation. This discussion will be confined to the steam locomotive, its progress in the recent past and its possibilities for the near future.

#### PROGRESS IN CAPACITY

While efforts individual in character and extent were made in this country before that time, the first consistent and systematic plan to secure the utmost power of locomotives within given restrictions of weight and cross-section clearance was inaugurated 20 years ago. This plan began with an eight-wheel or American type passenger locomotive, built for an eastern railroad in January 1895. This locomotive weighed 116,000 lb., with 74,500 lb. on driving wheels. It provided a tractive effort of 21,290 lb. While this locomotive was not the most powerful in passenger service at that time, it was the first of a chain of passenger locomotives leading in a connected series, by the same builders, up to and including recent designs of the Mountain type, representing the largest passenger type of present practice. This type has four-wheel leading trucks, eight driving wheels and two trailing wheels. The largest of the Mountain type weighs 331,500 lb. with 240,000 lb. on driving wheels and produces a tractive effort of 58,000 lb., or about three times the tractive effort of the first design of the series built during a period of 20 years.

In the year 1898 the engineering and railroad world was interested by the appearance of the largest and most powerful locomotive built up to that time. This was of the Consolidation type with a two-wheel leading truck and eight driving wheels. This locomotive was built in Pittsburgh and for a number of years was the largest and most powerful of its type, and the largest and most powerful locomotive in the world. Its total weight is 230,000 lb., weight on drivers 208,000 lb. and tractive effort 53,300 lb.

Today the most powerful freight locomotive has two leading and two trailing wheels and 24 driving wheels. It gives a tractive effort of 160,000 lb. and weighs 410 tons. This locomotive has hauled a train of 251 freight cars weighing 17,912 tons, exclusive of the locomotive. The total length of the train was 1.6 miles, the maximum speed attained was 14 miles per hour. This required a maximum drawbar pull of 130,000 lb. This locomotive has six cylinders and three groups of driving wheels.

A freight locomotive has recently been built having two cylinders and a single group of driving wheels which develops a tractive effort of 84,500 lb. Such has been the progress in capacity.

This progress has been rapid, perhaps somewhat too rapid with respect to improvements in operating facilities and progress in other features of railroad equipment. It has been rendered possible by corresponding developments of factors making for greater efficiency in boilers and in engines. During the past 20 years in this country locomotive development in capacity and in efficiency, particularly during the past five years with respect to efficiency, has been remarkable and is worthy of record with progress in marine and stationary engineering.

In Europe the relatively high cost of fuel led to efforts to improve efficiency before this problem aroused serious attention in this country, but physical limitations more rigidly restricted the size and weight of

locomotives in Europe. Our problem is to secure maximum efficiency combined with great size, great weight and great power which is more difficult. Since the development in the size and weight has been tremendous, even though these limits may not yet have been reached, it is now appropriate to concentrate on efficiency.

For a number of years the physical capacity of the fireman to shovel horsepower through the fire door determined the capacity of the locomotive at speeds. Mechanical stokers have removed that limitation. It is now possible to fire six tons, and more, of coal per hour into a locomotive firebox. This has changed the problem into one of getting the maximum amount of heat out of the coal and using it economically in the cylinders. With the large figures now prevailing for drawbar pull and weight it is fitting that closest attention should be given to the best possible use of every pound of metal and every pound of coal. Due to recent application of several economy producing and capacity increasing factors great improvements have already been made with promise of more to come. Then the great work of building up the efficiency of the average locomotive to the standard of the best will follow in natural course.

Among these economy producing and capacity increasing factors are the following improvements:

- Boiler design in relationships of the factors making up heating surface
- Firebox design
- Front end design, draft appliances, exhaust nozzles
- Ashpan design as to air openings
- Superheating
- Compounding
- Feedwater heating
- Firebrick arches and circulating supporting tubes
- Valve gear
- Detail design to secure reduced weight of reciprocating parts and other parts
- Use of high-grade alloy steels to reduce weights
- Mechanical stokers
- Labor-saving devices for the engineman and fireman
- Improved counterbalancing to permit of greater weight on driving wheels by reducing dynamic stresses
- And yet to come is powdered fuel with possibilities unknown in scope and in importance. Powdered fuel is in reserve, promising the ideal method of complete combustion under control more perfect than is possible with present methods other than oil burning and perhaps with economies impossible to obtain with oil.

### PROGRESS IN EFFICIENCY

Valuable comparisons may be drawn from the best results of ten years ago and of today. At the Louisiana Purchase Exposition in 1904 the tests made by the Pennsylvania Railroad revealed important figures concerning locomotive performance at that time. It was shown to be possible to obtain equivalent evaporation from and at 212 deg. of 16.4 lb. of water per sq. ft. of heating surface, indicating the power of locomotive boilers when forced. It was shown that when the power was low, the evaporation per pound of coal was between 10 and 12 lb., whereas the evaporation declined to approximately two-thirds of these values when the boiler was forced. These results compared favorably with those obtained in good stationary practice, whereas the rate of evaporation in stationary practice lies usually from 4 to 7 lb. of water per ft. of heating surface per hour. In steam consumption the St. Louis tests showed a minimum of 16.6 lb. of steam per i.h.p. per hr. In coal economy the lowest figure was 2.01 lb. of coal per i.h.p., the minimum figure for coal per dynamometer h.p. was 2.14 lb. These records were made after the superheater had become a factor in locomotive practice and they represent economies attained by aid of the superheater in one of its early applications. This is important in the light of the recent development of the superheater. These remarkable figures have never received the attention which they deserve from engineers. They serve, however, to show that 10 years ago a steam locomotive had attained results which were worthy of the best attention of the engineers of the time. Since then greater progess has been made and today locomotives of larger capacity than those concerned in the St. Louis tests have given better results.

Voluminous records of recent investigations of locomotive performance taken from the Pennsylvania Railroad test plant at Altoona show that the best record of dry fuel per i.h.p-hr. down to the present date is 1.8 lb. with a large number of less than 2 lb., while the best performance in dry steam per i.h.p-hr. is 14.6 lb. with a large number less than 16 lb. A reduction of 10 per cent in fuel and 12 per cent in water is remarkable as a result of a development of 10 years. This coal performance was recorded by a Class E6S Pennsylvania Railroad locomotive while running at 320 r.p.m. and developing 1245.1 i.h.p. The same locomotive gave a fuel rate of 1.9 lb. while running at the same speed and developing 1750.9 i.h.p. The best water rate was given by Class K2Sa Pennsylvania Railroad locomotive while running at 320 r.p.m. and developing 2033.1 i.h.p. These high powers indicate that the locomotives were not coddled as to output of power in order to show high efficiencies, but that high efficiencies accompany actual conditions of operation in severe service. As to power capacity expressed in terms of evaporation, it is interesting to note that the maximum equivalent evaporation from and at 212 deg. per sq. ft. of heating surface per hour on the Altoona test plant is 23.3 lb. These figures of high efficiency were obtained from locomotives which represented not only very careful, general and detail design, but their design included several of the improvements making

for greater capacity and higher efficiency, without which the results could not have been attained.

Having in mind the facts that steam locomotives are power plants on wheels, built to meet rigid limitations of weight, both static and dynamic, and that the use of condensers is impossible, engineers in general must admit the high character of the work of locomotive designers which has attained these results.

Greater efficiency which is revealed on the test plant and through reports of engineers would be important because it proves that progress is being made in the possibilities of locomotive performance. Improvement which is revealed by operating statistics and which, therefore, appears in the records of the treasurer's office is the real test in this case. It is important to know that increased power of locomotives attained largely through the development of economy producing and capacity increasing factors has produced results which the financial reports of railroads prove beyond question. A recently published list of train tonnage on 45 prominent railroads indicates that 16 of these roads have increased their average freight train loads by over 30 per cent during the last five years. Credit must be given to the improvement in the locomotive for most of this development. These figures reveal the value of increased power and efficiency of steam locomotives and the end is not yet in sight.

### WHAT REMAINS TO BE DONE

American locomotive development to its present state would have been impossible without the use of the improvements already mentioned. It is believed that all these are capable of still further development, making for still greater economy in the use of fuel and, therefore, promising greater power capacity. It is the object of your Committee to present these possibilities for discussion by those who are engaged in perfecting and improving steam locomotive practice in this country. It is the hope of your Committee that engineers who are devoting their attention to the design of locomotives as a whole and those who are engaged in the development of the various details which have contributed to the high efficiency of the steam locomotive of today will discuss the progress of the recent past and reveal possibilities for future development and improvement in capacity and efficiency.

G. M. Basford
F. H. Clark
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} *Sub-Committee of Railroad Committee*

# ABSTRACT OF DISCUSSION

F. F. Gaines contributed a written discussion in which he stated that boiler and firebox proportions must be carefully studied and chosen so as to produce capacity as well as efficiency. These proportions are now being worked out on a scientific basis. Modern large engines have a ratio of tube heating surface to total heating surface as high as 20. On small engines with deep fireboxes this ratio formerly ran as low as 8. A desirable figure for this ratio is 12. This can be obtained by the use of a combustion chamber which lengthens the firebox and shortens the flues. Where large grate areas are required, as in the large Erie Triplex, it is almost impossible to provide a wheel arrangement that would not necessitate the firebox extending over the drivers. With the use of a combustion chamber this can easily be accomplished, as the mud ring may be as high or higher than the bottom waist line of the boiler. The ratio of total heating surface to grate area should not be over 80, and more economical results are obtained if it is 65.

With ample grate area and firebox heating surface the desired results cannot be obtained unless the affiliated parts are correctly designed. The grates should be of such mesh as the grade of fuel requires; the mesh being as large as possible without the fuel dropping through. The grates should also have the maximum of possible air openings as well as air openings in the side bearers. The opening on the top should be a minimum and expand as it goes down, so that any ash, slate or clinker that can pass through the top will easily pass through and not clog the grates. Ash-pan openings are generally restricted and do not admit sufficient air for economical or maximum combustion. The proper arrangement of front ends is very essential to the uniform drafting of the fire; the lower the exhaust pipe, the less the back pressure and consequently the greater the mean effective pressure.

In this country feedwater heating is confined to a limited number of cases and cannot be said to be recognized generally as a factor in fuel economy. Experiments made on several engines by the writer showed about 10 per cent economy, which was considerably offset by difficulties in maintenance. Eventually, however, we will develop a type of feedwater heater that will eliminate the objections. It would appear that the most feasible plan would be a type of open feedwater heater, which would be located between the frames of the engine and underneath the boiler, using the exhaust from the air pumps, boiler feed pumps, and part of the main exhaust. In doing this it is thought that ultimately instead of using the present form of exhaust draft to effect combustion, with its consequent back pressure due to restriction of nozzle, a form of forced draft of the blower type will be used. Under these circumstances the exhaust openings from the cylinder to the atmosphere can be made without any restriction whatever, thereby greatly eliminating back pressure. The steam required for operating the auxiliary and forced draft would use but a small proportion of the horsepower gained. Previous experiments would also indicate that a type of centrifugal pump would be much more effective and positive for boiler feeding than one of the reciprocating type.

American railroad practice is averse to adding anything to the locomotive in the way of additional apparatus which complicates its operation or adds to its complexity. The demand for the utmost economy will eventually bring about a satisfactory method of feedwater heating so that in connection with superheating, liberal firebox heating surface,

and possibly compounding, we can obtain the maximum possible economy from the fuel used.

F. J. Cole called attention in a written discussion to the fact that in recent years, locomotives have increased so much in power that methods formerly employed are no longer adequate in proportioning the grate, heating surface, length and diameter of tubes, etc., when the class, tractive power and limitations of weight are known.

The size of cylinders is usually fixed by the permissible axle load allowed upon the track or bridges, in connection with the type, driving wheel diameter, boiler pressure and factor of adhesion. After these fundamental features are decided upon, the boiler proportions must be outlined to see whether the required amount of heating surface can be obtained without exceeding the limits of weight.

There are two general questions involved in the consideration of this subject, namely, how many pounds of steam per hour are required to supply the cylinders in order to develop the maximum horsepower; and what proportion of grate, firebox and tube heating surface will best produce this amount of steam.

The locomotive, unlike most steam plants, varies in the speed and power developed. It must be able to run at any intermediate speed between starting and its full velocity and at the same time develop all degrees of tractive power within its capacity. At slow speeds the maximum pull must be exerted in order to start the trains easily, and for this reason the live steam is admitted to the cylinder during 80 to 87 per cent of the stroke. As the speed increases it is necessary to reduce the admission period, thereby increasing the expansion of the steam. Therefore for any speed there is some point for the valves to cut off the live steam, at which the engine will develop its maximum power. There is also some minimum velocity at which the full horsepower of the locomotive is attained; after this velocity is reached the horsepower remains constant or slowly decreases. This critical point may be taken at 700 to 1000 ft. per minute piston speed.

It has been customary to use certain ratios, based on cylinder volume, for locomotive proportions. These ratios left to individual preference such matters as rate of combustion per square foot of grate, length of flues, evaporative value of firebox heating surface or value of tube or flue heating surface in relation to the length, making it desirable to proportion boilers upon more uniform methods in which these variable factors are given due consideration.

The writer collected a considerable amount of data on this subject and drew up a report with the object of reducing this matter to a more uniform basis, substituting for the ratios hitherto employed, cylinder horsepower requirements. Suitable values were assigned to grate surface, tube heating surface, etc., with corresponding evaporative values, so that the balance between the amount of steam required by the cylinders and the amount of steam which the boiler was capable of generating could be expressed in percentage of cylinder horsepower. The tests made on sectional boilers on the Northern Railway and the Paris, Lyons & Mediterranean Railway of France, those of Dr. Goss on a Jacobs-Shupert boiler, and tests by the Pennsylvania Railroad on the Altoona testing plant were examined in order to obtain data on which to base the evaporative values of different points of the boiler. It is obvious that the evaporative value of a boiler tube of given diameter varies greatly with its length. The temperature of the firebox is fairly constant under similar conditions of draft and rate of combustion, therefore the temperature of the smokebox will be reduced with an increase in the tube length. While some additional draft will be required to draw the gases through the tube, yet the net result is a greater temperature absorption between the firebox and smokebox. The thermal efficiency of the engine is increased within certain limitations by the use of long flues. The economical length of tube is determined mostly by the number and arrangement of wheels of the engine required and only partly by thermal conditions.

About 1899 the wide firebox Atlantic (4-4-2) type was introduced. Because the firebox was placed behind the driving wheels, the grate surface could be made to suit the power of the locomotive. It was, therefore, no longer necessary to force the rate of combustion as heretofore to 180 and 200 lb. per sq. ft. per hour. Very uneconomical results had been obtained when high rates of combustion were necessary, as much unburned coal was drawn through the tubes into the smokebox and thrown out through the stack by the violent draft. With the Atlantic, tubes of 15 and 16 ft. and sometimes longer were necessary. While at first some apprehension from leakage was felt with tubes of this length, it was soon found that there was no more difficulty in maintaining long tubes in good condition than short tubes. With the introduction of the Pacific (4-6-2) type, the Mikado (2-8-2) type and other locomotives having trailing trucks, still longer tubes were required. Tests made on long tube boilers, compared with older locomotives having shorter tubes, showed a noticeable reduction in smokebox temperatures.

Instead of the old arbitrary and unsatisfactory method of designing heating surface by cylinder ratios, the idea of using the cylinder horsepower suggested itself as forming a very desirable basis. Curves were prepared from the most recent available data showing speed factors or drop in m. e. p. in relation to velocity. With saturated steam the average maximum horsepower is reached at about 700 ft. piston speed per minute, speed factor 0.412; constant horsepower is obtained at 700 to 1000 ft. piston speed, and then slightly decreasing at higher velocities for average conditions when engines are especially constructed for the highest speeds. For superheated steam the average maximum horsepower is reached at 1000 ft. piston speed, speed factor 0.445 and constant horsepower at higher speeds. Because the horsepower is based on piston speed, the stroke and diameter of wheels are omitted in the following figures, the calculation for saturated steam becoming by cancellation:

$$\frac{0.85\ P \times 0.412 \times 1000 \times 2A}{33{,}000} = 0.0212 \times P \times A$$

in which

$A$ = area of one cylinder in sq. in.

$P$ = boiler pressure

0.412 = speed factor

In a similar manner the horsepower calculation for superheated steam becomes

$$\text{h.p.} = 0.0229 \times P \times A$$

using 0.445 as the speed factor.

The maximum horsepower can sometimes be increased when the locomotive is operated under the most favorable conditions. It is considered safer to take figures which

represent average conditions rather than the unusual figures obtained when all conditions are most favorable.

The horsepower basis affords many additional advantages in designing locomotives. For instance, in determining the maximum amount of water and coal required per hour, the size of the grate is found to be proportional to the amount of coal that can be burned to the best advantage, to be varied according to the quality. Knowing the amount of coal required per hour directs attention to the question of hand firing or the use of a mechanical stoker. Knowing the amount of water evaporated per hour determines the location of water stations, size of tender and tank, and also forms the basis for other features of the boiler, such as stack, size of injectors, safety valve capacity, and the size of steam pipes.

From the reports of Pennsylvania Railroad testing plant at St. Louis and Altoona, and from road tests, the conclusion is reached that a horsepower can be obtained from 25 to 29 lb. of saturated steam in simple cylinders with piston speeds of 700 to 1000 ft. per minute. A fair average value has been taken as 27 lb., and in a corresponding way 23½ lb. for compound engines, 20.8 lb. for steam superheated 200 deg. and over, and 19.7 lb. for superheated steam used in compound cylinders. These figures provide steam for auxiliaries. While careful tests show that the evaporation can be increased under the most advantageous conditions, it is considered better practice to take the lower figure in order to provide a margin for average conditions.

Pyrometer tests recently made by the Pennsylvania Railroad at Altoona with various locomotives on the testing plant showed the temperature curves of tubes of various lengths and diameter. From these curves the increase or decrease of tube evaporation may be calculated. Short tubes have much greater evaporative value per square foot of heating surface than long tubes, but they discharge the gases into the smokebox at much higher temperatures. Therefore, while the heat absorbed per foot of length is much greater for short than long tubes, it is not so economical, and the short tube boiler, other things being equal, requires more coal for a given evaporation. Where tube lengths of 12 or 14 ft. were common 14 or 15 years ago, lengths of 20, 22 and even 24 ft. are used in the modern locomotive. The result is that the smokebox temperatures have decreased from 750 to 800 deg., to 550 to 600 deg., the only increase of energy required being the slightly greater draft in the smokebox to pull the gases through the long tubes. This is not intended as a defense of the long tubes in modern engines, especially of the 4-6-2, 4-8-2, Mallet and other types, because in most cases their construction requires long boilers. Nevertheless tests show that economy results from the better utilization of heat in the modern engine than in older types because the range of temperature between the furnace and the stack is greater with the long tube locomotive.

As a result of these investigations, conclusions have been arrived at as follows:

*Firebox evaporation.* An evaporation of 55 lb. per sq. ft. of firebox heating surface, combustion chamber and arch tubes has been adopted. The greater absorption of heat by the firebox than by the rear portion of tubes per unit of area is largely due to radiant heat. This varies as the square of the distance from the surface of the fire to the sheets separating the gases from the water. Again it is probable that within certain limitations, the amount of heat absorbed is independent of the heating surface and is a function of the grate area or the area of the bed of live coals. Assuming that there is sufficient heating surface to absorb the radiant heat, it is probable that very little additional heat will be absorbed by increasing the firebox heating surface. It therefore follows that the relatively greater area of the fire in proportion to the absorbing surface in wide firebox locomotives is more efficient than in the old narrow firebox.

*Diameter, Length and Spacing of Tubes and Flues.* The evaporative value in pounds of water per square foot of outside heating surface has been approximately calculated for 2-in. and 2¼-in. tubes, and for superheater flues of 5⅜ in. and 5½ in. The range of length is 10 to 25 ft., and the spacing $\frac{9}{16}$ in. to 1 in. The best available data show that the evaporative value of a tube or flue varies considerably with differences in length, diameter and spacing. Curves of temperature compared with length have been used as a basis for determining the evaporation for different lengths of tubes and flues. The rate of evaporation on this basis will vary directly as the difference of temperature of the tube or flue gases and that of the steam contained in the boiler.

Tubes and flues from 10 to 24 ft. long, spaced $\frac{9}{16}$ in. to 1 in., outside diameter 2 in., 2¼ in. and 5½ in., will evaporate from 7.50 to 14 lb. per sq. ft. per hour.

*Grate Area.* Grate area required for bituminous coal is based on the assumption that 120 lb. of coal per sq. ft. of grate per hour is a maximum figure for economical evaporation. While 200 and 225 lb. have at times been burnt in small, deep fireboxes and the engines made to produce sufficient steam, it is wasteful of fuel and it has been found after numerous and careful tests, that the evaporation per pound of coal under these conditions is very low. If the rate of combustion is too slow, economical results will not be produced owing to the fact that at least 20 per cent of the coal burned produces no useful work in hauling trains, but is consumed in firing up, waiting at roundhouses or terminals, on side tracks, or to the fact that the greater portion of the time locomotives are used at considerably less than their maximum power.

For hard coal the grates should be proportioned for a range of from 55 to 70 lb. of coal per sq. ft. per hour, according to the grade of the fuel.

Complete tables of horsepower for saturated and superheated steam, evaporation of tubes and flues of various length, diameters and spacing, and diagrams of temperature of flue lengths have all been prepared to facilitate the calculations in determining the proportions of grate, firebox, tube and flue heating surface.

It must be remembered, however, that the boiler capacity for a locomotive, when other things are in proportion, cannot usually be made too large within the permissible limits of weight, and it can be shown by numerous tests that such increase in boiler capacity makes for considerable economy in the use of fuel and steam. For passenger service the boilers may often be made with advantage over 100 per cent.

In a general way, a boiler will have ample steam making capacity if proportioned by this method for 100 per cent,

provided the grate is sufficiently large and deep so that the rate of combustion at maximum horsepower does not exceed 120 lb. per sq. ft. of grate per hour for bituminous coal of average quality. For gas coal a smaller grate may be used, but it is better practice to use the larger grate and brick off a portion at the front end in order to obtain sufficient volume of firebox for proper combustion, because nearly all large modern engines are deficient in firebox volume.

C. D. YOUNG in discussing Mr. Cole's remarks, pointed out that some few years ago when large boilers were designed, the tendency was to make the ratio of the firebox heating surface to the total heating surface less than 6. This practice resulted in locomotives which, while efficient in evaporation, were not free steaming, as they lacked capacity unless very heavily drafted. Firebox heating surface should be at least 7 per cent of the total heating surface of the boiler. When this ratio is attained, good results will follow provided the tube heating surface has been properly proportioned. It should be realized that firebox heating surface is of comparatively greater effectiveness at mean and low rates of working than the remaining surface of the boiler. When working at high rates of evaporation, the tube surface is fully as effective as firebox surface, and for large capacity a large tube heating surface is necessary.

Beyond a certain length of tube there is too great a sacrifice of boiler capacity in the interest in economy in coal. The long tube presents a very serious resistance to the flow of the gases, and beyond a length—which appears to be about 100 internal diameters—this resistance increases without a corresponding increase in evaporation. The locomotive with a long tube is a slow steamer and a higher draft must be furnished in order to create an active fire. This rule—length of tube to be 100 times the internal diameter—has been applied to three new classes of Pennsylvania locomotives with exceedingly gratifying results; and confirms the earlier experiments made by the Pennsylvania Railroad upon this subject, as well as those made by M. A. Henry of the Paris, Lyons & Mediterranean Railroad of France.

J. T. ANTHONY in his written discussion remarked that from a furnace point of view, the principal points to be considered are grate area, flameway or volume, firing clearance and air supply. From the boiler point of view we must consider the extent and location of the heating surface.

In order to secure high efficiency, the grate area should be sufficient to keep the maximum rate of combustion below 100 lb. per sq. ft. per hour at full boiler capacity, as the losses due to imperfect combustion, cinder discharge, front end gases, radiation and unaccounted for losses increase rapidly above this rate with a corresponding decrease in boiler efficiency.

The high efficiency at lower rates of combustion is due not only to a reduction in the heat losses enumerated above, but also to the relatively large proportion of the total evaporation that takes place around the firebox. Most of the heat received by the firebox heating surface is radiated directly from the fuel bed and luminous flames, only a small amount being due to convection or direct contact. The amount of heat received by radiation depends on the area of the radiating surface and the difference in temperature between the radiating and cooling surfaces.

Flues receive their heat by convection, and the amount of heat so received, other things being equal, depends on the weight of the gases going through them. This varies with the rate of combustion, and as this rate increases the flue evaporation increases. Under the same conditions the firebox evaporation increases somewhat, due to the slightly higher temperature and increase in mass of flames, but not nearly as fast as the flue evaporation.

High firebox evaporation means high boiler efficiency, for the high heat absorption by the firebox reduces the temperature of the gases entering the flues; and for any one boiler, the temperatures of the gases entering and leaving the flues are directly proportional when reckoned above steam temperature. Hence a lower temperature of entering gases means lower front end temperatures and an increase in efficiency.

A large percentage of the bituminous coal burns above the grate as gas. The rapidity and completeness of the combustion of these gases depend on the amount of oxygen present and the thoroughness of the mixing. In a firebox with 60 sq. ft. of grate, with a rate of combustion of 60 lb. of coal per sq. ft. of grate per hour, an air supply of 20 lb. per lb. of coal and an average firebox temperature of 2000 deg., the volume of the gases evolved is about 1200 cu. ft. per second. A firebox of this size would have a cubic capacity of about 200 ft., and would have to discharge and be refilled with gases about 6 times per second. The average time available for combustion of each particle of gas would be insufficient for complete and proper mixing by diffusion. With the short time allowed, it is necessary to mix the gases by mechanical means, and this is generally accomplished by an arch or baffle which forces the gases through a restricted area, this area being not less than the net flue area.

Mere firebox volume is not sufficient of itself. It is necessary to have a flameway of such cross-section and length as to mix the gases intimately and provide sufficient space for burning before gases reach flues. In an ordinary firebox, without baffle or combustion chamber, the average length of flameway is only 5 or 6 ft. By the introduction of baffles and combustion chambers, this length can be increased from 10 to 15 ft., which results in not only more complete combustion but also in increased radiating surface, with a corresponding increase in firebox evaporation and a lowering in temperature of the escaping gases.

High efficiency is obtained at low rates of combustion in spite of the large air excess. The firebox absorbs a larger percentage of the heat evolved, and the amount so received depends primarily on the temperature of the fuel bed. It is possible that this temperature is higher with large air excess.

Firebox evaporation depends primarily upon the extent and temperature of the radiating surfaces and not on the extent of the heating surface. Increasing the firebox heating surface without increasing the grate area or flameway will result in very little increase in evaporation. An evaporation of 60 lb. of water per sq. ft. of firebox heating surface requires a difference of less than 100 deg. between the water and the fire side of the sheet. If sufficiently high firebox temperatures or radiating surfaces could be

obtained, it would be possible to increase this high rate of evaporation without forcing the heating surface to its capacity.

In the Coatesville tests, the two fireboxes gave an evaporation as high as 58 lb. of water per sq. ft. of heating surface. There was practically no difference in the total evaporation by each of the fireboxes when working at the same rate of combustion and with the same grate area. One of the fireboxes had 12 per cent more heating surface than the other.

Unless the fuel is materially changed, we are not likely in the near future to see any radical departures from the present type of firebox. Any improvement in the firebox efficiency will be obtained by paying particular attention to and making ample provision for grate area, firing clearance, gas mixing, flameway or combustion chamber space, and air supply.

H. B. MacFarland offered a written discussion in which he called attention to the amount of experimental work that has been done to determine the most efficient arrangement of drafting appliances, and yet it has been often and thoroughly demonstrated that the best arrangement for a front end for any given locomotive can only be determined after careful tests in service.

Pioneer work in this country in establishing scientifically the fundamental principles of front end action was done in the locomotive testing laboratory of Purdue University. The rapid development of powerful locomotives in the past few years calls for such an increase in the boiler capacity that it was questioned whether these recommendations were still applicable to the newer types of power. In order to demonstrate the best type of drafting, the Pennsylvania Railroad recently made a series of front end tests. Definite results and recommendations were obtained only after a very well worked out series of tests with a large number of different front end arrangements. From results obtained, however, they were not able to establish recommendations governing a proper design of front end appliances which may be generally applied to all classes of locomotives, so that such an arrangement has to be left to individual tests for each class.

That the present practice of locomotive drafting is accomplished at the expense of back pressure acting against pistons has been generally understood for a long time. Although generally understood that back pressure exists in all locomotives, the magnitude of the power loss due to this back pressure has not been generally recognized.

Since draft is a function of the front end arrangement in general and of the exhaust tip in particular, it naturally follows that the operation of the high powered locomotive boilers of the present day is at the expense of a very pronounced back pressure due to restricted tip. This is particularly true when the locomotives are operated at such rates of power as to force boilers to their maximum. Data were collected from tests conducted upon 18 different locomotives representing as many different types and working under such varied conditions as are encountered upon the Sante Fé System. These data show that for every 100 h.p. used as actual tractive power, there are 66 h.p. wasted through the exhaust, over 70 per cent of which may be credited to the excessive back pressure necessary to produce draft for the locomotive boiler.

The total capacity of a locomotive boiler has been greatly increased during the past 10 years by the development of auxiliary apparatus such as superheater, brick arch, feed-water heater, stoker and other labor saving devices. An increase in boiler capacity has also been accomplished indirectly by improving the efficiency of the locomotive through improvements made in the valve gear, cylinder design, properly designed steam passages, etc. With all the developments and improvements, however, the fact remains that the determining factor in increased boiler capacity is, under the present arrangement, increased draft, and it follows that the most efficient method of producing this draft should be given serious consideration.

During complete tests made in the summer of 1914 of four different Prairie type locomotives, experiments were made to determine the effect of changes in front end arrangement. In each instance a number of runs were first made with the front end, as far as possible, in accordance with recommendations of the American Railway Master Mechanics' Association. Changes were then made in the front end arrangement to make each locomotive conform generally to the latest recommendations of the Pennsylvania Railroad. Assuming an efficiency of 100 per cent for the original arrangement, the tests show that a draft of 6 in. in the front end was produced with the new arrangement at a saving of 34.5 per cent in back pressure produced in the cylinders.

These tests show what may be accomplished by changes in front end arrangement, but when it is considered that the efficiency of the front end is very low from a thermodynamic standpoint, these gains in efficiency have very little effect on the total efficiency of the locomotive.

The power performance curves for one of the locomotives tested show that its maximum power was reached at a speed of 35 miles per hour; the locomotive developing 1350 i.h.p. and having 190 back-pressure h.p. There was a gain of 35 per cent in front end efficiency with the new front end arrangement. This means that the same draft was produced with a reduction of 35 per cent in back pressure, or at a saving of 66 h.p. This results in an increase of but 5 per cent in the capacity of the locomotive.

Curves taken from tests on a 2-8-8-2 Mallet show that maximum power was developed at a speed of approximately 17 miles per hour and that drawbar horsepower and back-pressure horsepower equalized at a speed of approximately 25 miles per hour. At this speed the locomotive exerted 950 drawbar h.p. and an equal amount was required to draft the boiler.

These tests have forcibly demonstrated the inefficiency of the present arrangement when viewed from a thermodynamic standpoint. The chief advantage of the present arrangement is mechanical efficiency; that is, it is free from any complicated parts and requires only minor adjustments. It is this feature alone that has enabled the present front end to exist to the present day.

In view of existing conditions, attention was attracted to the possibility of drafting by some method of forced or induced draft. Because of the impractibility of installing a system of forced draft, this form was abandoned. Induced draft has been successfully applied in stationary and marine service. The development of the steam turbine and progress in theory and construction of centrifugal fans make it seem logical that if the system could be so success-

fully applied to other fields it would find ready application to the locomotive. When the problem was presented to the manufacturers, they were able to calculate the size of the fan and the horsepower necessary to drive it to burn the required amount of coal. But when the space that such an apparatus would occupy was taken into consideration, they were unable to furnish either data or apparatus to meet the requirements satisfactorily. For this reason it was absolutely necessary to start in at the beginning and to develop such an apparatus.

After many experiments the MacFarland fan draft was developed. The diaphragm, nozzle pot, netting and other draft appliances were removed, leaving the front end clear for the reception of the turbo-fan unit. The smokebox proper was divided into two compartments by means of a sheet iron, air-tight partition, which made connection between the intake opening in the fan casing and the inner ring of the smokebox arch. The compartment next to the front tube was thus made separate and constituted the front end proper, the only opening being directly into the inlet of a high-speed direct-connected, centrifugal fan. The remaining compartment acted as a general housing for the fan and its operating power unit. Cylinder exhaust was led directly to the atmosphere by means of pipes leading from the front heads of the steam chest to a common stack located just ahead of the fan exhaust stack on top of the boiler. When the locomotive was working, the steam for the turbine was taken directly from the superheater; when the main throttle was closed the turbine was supplied through the blower line. While the fan used during this experiment was not mechanically correct or of sufficient capacity to develop the maximum power of the locomotive, it brought out many valuable points relative to the general performance to be expected from a system of this kind.

The experience gained led to the design of a larger fan unit which was applied to a New York Central switcher and a comparative test was made before and after installation. This installation was never satisfactory from a mechanical standpoint, because the unit employed was not adapted to the size of the smokebox on this particular locomotive. The tests further demonstrated, however, the possibilities of this form of draft for locomotives and justified the following conclusions:

(*a*) That the engine could be successfully drafted with the MacFarland fan draft. A maximum of 9 in. of draft was developed in the front end with an average of 8¼ in. throughout one of the test runs, and the fan operated successfully against depths of fire ranging from 6 to 18 in.

(*b*) That the exhaust could be muffled to any desired point by the introduction of proper netting stages.

(*c*) That the engine could be operated practically smokeless.

(*d*) That the engine burned a uniform and intense fire.

(*e*) That full operating steam pressure was readily maintained.

(*f*) That the back pressure on the engine was entirely eliminated.

(*g*) That it was not necessary to use the exhaust steam for drafting the engine.

These tests have furnished data for the design of a special unit to overcome the mechanical difficulties which have been brought out. The experience gained has also led to the development of an automatic control system to govern the speed of the turbine and consequently regulate the intensity of the draft.

C. E. Chambers remarked that he had used long and short stacks, rectangular and oblique, single and double, but thought that the single type would give satisfaction if other things were right. The height of the exhaust pipe should be not more than one-quarter to one-third.

Front end diaphragm arrangement has a lot to do with an engine freeing itself. It must be kept 6 to 9 in. away from the sheet to give a clearance.

Many railroads have trouble from smokebox fronts overheating. This difficulty can be eliminated by placing the liner about 4 or 5 in. away from the door and filling with asbestos.

C. D. Young gave statements based on facts developed by observation of locomotives on the testing plant at Altoona. These tests, during the last 10 years, embrace 23 passenger and 17 freight locomotives.

General use of the Schmidt type of superheater has had an influence in effecting a certain uniformity in the arrangement of the smokebox. The one-piece lift-pipe, connected directly to the outside of the stack, forms a very desirable and simple arrangement. Requiring only a short exhaust column, the advantage of a long stack may be obtained. A petticoat pipe, with its adjustable features, is not so desirable as the internal single-lift pipe. These adjustable features are a source of annoyance in that people not properly qualified are continually tampering with the arrangement, which results in an improper draft. It is most desirable that the gases have a free passage through the smokebox, and all possible restrictions between the tube sheet and stack should be carefully investigated as to their areas. Care should be taken to provide a passage through the superheater damper, which is at least equal to the area of the boiler and superheater tube outlets above the damper.

On railroads where there is practically little or no drifting, there would seem to be no requirement for a superheater damper. However, where a moderate amount of drifting is done, or where the locomotives are interchanged between divisions with few and moderate grades and divisions with heavy grades requiring a large amount of drifting, the automatic damper is a most essential feature for the protection of the superheater elements.

There has been a tendency of late to use exhaust nozzles having other than circular openings. The plain circular nozzle forms a steam jet which is too nearly cylindrical, or the shape of the stack, and the use of such a shape as the rectangular appear to break up the continuity or form of the jet and cause it to draw out a larger volume of gases. Both rectangular nozzles and nozzles of the dumbbell shape have been used to success and with an increase in evaporation over that of the circular form. There has recently been developed on our testing plant a nozzle having four internal projections which appears to be more satisfactory than some of the irregular forms. With nozzles having other than a circular outlet, an increase in the evaporative capacity of the boiler of from 15 to 25 per cent has been obtained. In recent tests upon a large Pacific type, a nozzle with four internal projections has given a

maximum capacity in equivalent evaporation, from and at 212 deg., of 87,414 lb. per hour. This is an evaporation of 18 lb. of water per sq. ft. of heating surface per hour. With this capacity, an i.h.p. of 3184 was obtained. This same locomotive with a circular nozzle developed a maximum equivalent evaporation of 62,719 lb. of water per hour, resulting in an i.h.p. of 2501. No other change, other than in the exhaust tip, was made in the locomotive. The back pressure in both cases was practically identical.

Mr. Young also called attention to ashpan design as to air openings. He remarked that the air openings into the ashpan should be at least 15 per cent of the area of the grate. When the openings are of this size, the ashpan vacuum will be considerably less than one inch of water at the maximum evaporative rates.

This ratio has been found to be too large for the requirements of some switching engines. By installing ashpan dampers along the air inlets at the mud ring, this difficulty has been overcome. If the air inlets, in the ashpans of locomotives which stand around a large part of the time, are not reduced, it would be difficult for the fireman to prevent a large amount of steam from escaping from the safety valve.

H. B. Oatley in presenting a written discussion on superheating stated that the locomotive boiler presented many limitations that have an important bearing on the design and construction of the superheater. The development of the locomotive, within certain fixed clearances, has been dependent upon the size of the boiler. As the boiler increased, wheels have been added to obtain proper weight distribution. Consequently, the boiler is no larger than is absolutely necessary and in the majority of cases it is insufficient in evaporating surface.

The application of a superheater to this boiler necessitates a reduction of about 15 or 20 per cent in the tube heating surface. Furthermore, a certain percentage of the gases, which formerly was available for evaporation of the water, must now be used for superheating the steam.

Taking this boiler with its deficiencies, the superheater has produced an economy of 25 per cent in fuel as a direct result of saving 33½ per cent of the total water evaporated per unit of power. As a result of this fuel economy, greater capacity of the locomotive has resulted.

If cylinder tractive power in per cent is plotted against piston speed, it will be seen that the average modern superheated steam locomotive, using between 200 and 250 deg. of superheat, has a greater available tractive power. This is due to the fact that a longer cut-off is possible with the superheater engine at comparative speeds. The limiting factor at the usual speeds is the ability of the boiler to furnish steam.

These results have been accomplished in the face of boiler limitations, parts of the locomotive being not adaptable to the use of highly superheated steam, and lack of experience in the organization which must handle the locomotive. The problems incident to these conditions are rapidly being worked out, and results shown by the superheated steam curve will soon be as basic as the saturated steam curve was a few years ago. The future holds a possibility for further saving by increasing the degree of superheat. For some time past large passenger locomotives have been operated very successfully with steam chest temperatures between 750 and 800 deg. This corresponds to 350 to 400 deg. of superheat.

The superheater engineer has only made use of the same variety of flue sizes as was used by the locomotive designer for tube sizes. If the superheater designer should be permitted the use of a size different from the two present standards, it would be possible to obtain in a superheater boiler, evaporating surface practically as great as in the saturated steam boiler. In this case the superheating surface would be a distinct net gain to the heat absorbing surface of the boiler. With a boiler and superheater thus arranged, greater capacity may reasonably be expected.

C. D. Young remarked that it is now known that the economy due to superheating increases almost directly with the degree of superheat; and the usual type of fire-tube superheater produces its maximum superheat only when it is forced to the limit of boiler capacity.

This condition is not altogether desirable as the maximum economy should be obtained when the locomotive is working under moderate or average conditions and at an economical cut-off. A superheater that would give a uniform superheat under all conditions of working would apparently produce ideal results.

If our materials, in valves, cylinders and packing, as well as the lubrication, will withstand a certain high degree of superheat, there is no reason why we should not furnish this degree of superheat regardless of the boiler rate in order to effect the greatest economy in steam. With the usual Schmidt superheater we have observed steam temperatures as high as 670 deg., corresponding to a superheat of 291 deg. at a steam chest pressure which was 180 lb., while the boiler pressure was 206 lb. With these conditions the steam rate per horsepower hour was 19.3 lb., the speed 47 miles per hour, and the cut-off 50 per cent. With this superheat and cut-off at 25 per cent, it is reasonable to suppose that a water-rate approximating 15 lb. could be obtained. For this reason the desirability in future designs of superheaters is to produce, if it is possible, a superheater that will give us a uniform superheat regardless of the evaporation of the boiler. Until such a superheater has been produced the maximum economy and capacity from the boiler cannot be obtained under all working conditions.

C. J. Mellin presented a written discussion on compounding and in commenting on the course of progress in steam engineering, he said it was but natural that the compound engine, which had been so successfully introduced into marine and stationary service, should find its way to the locomotive.

Difference in conditions under which the locomotive operates as compared with the marine and stationary engines, in that its greatest resistance is in starting, was not fully realized in earlier attempts to introduce the compound into railway service. Various means were later employed to compensate for this difference, but for many years the compound was looked upon with suspicion.

Very little improvement, however, was made in the simple engine until the compound commenced to show its superiority by hauling heavier freight trains with the same weight on drivers as the simple engine and with a considerable reduction in fuel and water consumption, reduction in boiler repairs, improvement in smooth riding qualities, and the

practical elimination of jerks in starting, thus making a saving in car and draft gear repairs.

To compete with these advantages the simple engine was enlarged both in boiler and cylinder capacity, necessitating an increase in weight, and for a number of years the contest for supremacy was on, ending only when the limit of the right of way stopped the further enlargement of the low-pressure cylinder of the cross-compound engine; the permissible diameter being 36 in., or an equivalent to a 21-in. simple engine. The Vauclain four-cylinder compound, the four-cylinder balanced compound and the tandem compound followed, but all soon found their limitations.

The three-cylinder compound would have been the natural successor to the cross-compound but for the complications involved in applying the central main rod across the main axle, as was necessary on other than four coupled engines. Its introduction was, therefore, deferred indefinitely. Nevertheless, various designs of this type have been worked out to the equivalent of a 26-in. simple engine.

Instead of entering on this complication, a step still further in advance was taken about 12 or 13 years ago, when, after close investigation as to the best means of employing two low-pressure cylinders, the Mallet method of articulation was selected. The first design was made during the summer of 1902, retaining the American Locomotive Company's compounding system and American methods of construction throughout.

Up to this time there were few engines with higher tractive power than 40,000 lb. The bold idea of stepping up to 72,000 tractive power in compound gear and 86,000 in emergency was severely criticized. After long and serious consideration the Baltimore and Ohio Railroad decided to have an engine built to these proportions. Hardly had the engine started in regular service when its real qualities were discovered and its performance viewed with surprise. Reports of the result obtained caused personal investigations to be made by railway officials and resulted in a decided reversal of an unfavorable opinion to that of recognition of its advantages. At present 115,000 lb. in tractive power in compound and 138,000 lb. in emergency are being produced in very successful service and plans are worked out, ready when required, for engines of this type giving 140,000 lb. tractive power in compound and 168,000 lb. emergency power.

The next step for heavy power, where road conditions permit, is triple articulation, using the tender as the third unit. One engine of this type has been built having 160,000 lb. tractive power, but as yet it may be considered as experimental. On account of the limited boiler capacity on such engines, it may be necessary to make the tender engine independent of the other two units, subject to regulation at will, in order to get the maximum amount of steam for fanning the fire. The exhaust from the tender engine has very little effect by the time it reaches the stack and may therefore be carried direct from engine to atmosphere. Mechanical draft could probably be applied to advantage as a further means of increasing the boiler capacity at the slow speeds at which such an engine would naturally operate. By this means a tractive power of over 200,000 lb. could be obtained.

In the meantime the superheater has proved to be of great advantage in compounding. Practically all the superheat in the steam can be used before its final exhaust, and condensation during the latter part of its extended expansion is eliminated. This combination of compounding and superheating, when proper cylinder proportions have been observed, affords the greatest economy in locomotive operation.

Mechanical stokers have made possible the further enlargement of engines. It is also probable that mechanical draft in combination with a feedwater heater, will be an additional feature in the direction of economy, because of the possibility of running the boiler to its required capacity regardless of the speed of the engine. It also removes the unavoidable loss of power caused by back pressure in the cylinders, which loss increases with the size of the engine.

H. H. Vaughan, in discussing feedwater heating, called attention to the experiments that are being made with exhaust steam heaters, and waste gas heaters on the front end by Mr. Travithic on the Egyptian Railways. With the waste gas heater he has been able to put the water into the boiler at 250 deg. and obtain 22 per cent economy.

On the Canadian Pacific, experiments with open heaters in a tank have given fairly good satisfaction. We also applied exhaust-steam injectors to some engines and got fair results, but found that to operate them satisfactorily we should have an exhaust nozzle. We have since been advised by the manufacturers that our troubles were because of our having applied too large size an injector. While exhaust steam injectors work fairly well under certain conditions, yet there would be difficulties where the amount of water consumed would be large.

Experiments on an open heater showed that the temperature obtained from the exhaust-steam was due to the exhaust-steam from the feed pump. A temperature of 200 deg. in the feedwater is the equivalent of 160 deg. when water is put into the boiler by an injector with 100 per cent efficiency. By heating the water at the injection suction to 120 deg., we got 6 per cent economy using injectors, which we thought preferable to 10 or 12 per cent using a pump. Lately we have experimented with an ordinary closed feedwater heater.

Feedwater heating is a subject which railroad people on this side have neglected. It has the advantage of not only saving coal but increasing the capacity of the boiler, as the temperature of the water in the boiler would not be materially changed. My feeling about the heater is that we will see it coming into larger use not only with exhaust steam but with waste gas.

J. P. Neff in speaking on firebrick arches and circulating supporting tubes stated that about ten years ago very few railroads were consistently using brick arches. A number of roads were tolerating them in a very small percentage of their engines, and a large number had discarded them entirely.

As the locomotive itself has been greatly improved during the last ten years, so has this particular device. It has been shorn of many of its original faults, leaving its never disputed virtues standing out all the more prominently.

Briefly, the arch insures more nearly complete combustion. The combustion of high volatile coal at the rapid rates necessary to meet the demands for large hauling capacity, is fraught with considerable losses due to incompleteness. That represented by the CO content in front end gases is only a part. Losses from incomplete combustion of hydro-carbons may easily be four times that represented by the CO per cent in the gas analysis. Anything that will mitigate

these losses without introducing too high air excess reflects at once in higher furnace temperatures. Combustion chambers help by lengthening the flame travel, but the arch, especially the arch on water tubes, not only doubles the average length of the flame travel, but in addition possesses the more important virtue of a mechanical mixer.

By enhancing combustion over the fuel bed, considerable more heat is involved and higher firebox temperatures result. Authentic tests have shown that with certain coals this increase in temperature may be 15 per cent. As a rule, these higher firebox temperatures are not accompanied with higher front end temperatures. Thus the double result of creating more heat and causing it to be absorbed, is accomplished.

Circulating tubes or arch pipes not only present the most effective heat transmitting surface, but the circulating effect is very important, especially at high rates of combustion. As the particles of gases must quickly touch the heat absorbing surface and give way instantly to other particles, so must the water on the opposite side of these surfaces, if a high rate of heat transfer is to be accomplished. Expedited circulation will insure this favorable condition. A locomotive boiler cannot give high duty per square foot of surface when the gases move leisurely.

Arch tubes, as they are now, give much aid, but there is still more to be done in this direction. Arch tubes or circulating water tubes through the firebox may be used in still greater number with good results, if properly arranged and disposed so as to aid in mixing mechanically and in circulating without too quickly lowering the temperature of gases.

G. W. Rink in reading a written discussion on valve gear and cylinders said that while every effort is being made to increase the efficiency of the boiler, it appears that the economical distribution of steam in the cylinders has also received some attention. In general, however, we are not getting the good results such as are obtained in good stationary engine practice. This is due to long steam ports and the use of a single slide or piston valve which has to control admission, cut-off, release and compression.

A design of cylinder overcoming these objections has been introduced in recent years and is known as the Hobart-Allfree cylinder. A comparative test was made on the Jersey Central with an engine fitted with this type of cylinder and slide valves as against another engine fitted with the regulation cylinder and slide valve. These tests showed an economy in fuel and water consumption of approximately 12 per cent. Tests conducted on other railroads with Mallet engines equipped with the same style of cylinder and slide valve showed, with practically the same amount of coal per ton mile, an increase of 13½ per cent in tonnage hauled with an increase in speed of 4.3 per cent and a saving of water per ton mile of 11.1 per cent.

Valve gears have received a great amount of attention in recent years and a design which has apparently met with considerable success is known as the Baker valve gear. This gear was designed with a view of replacing the old inside link motion. It has also been applied in preference to the Walschaert gear in many instances owing to objections due to links or sliding blocks. The Baker gear has all bearings provided with pins and bushings which are more readily inspected and repaired.

W. E. Woodard discussed detail design to secure reduced weight of reciprocating parts and other parts. He stated that in all designs it is necessary to get as large a boiler as possible, consistent with the proper design of the other parts of the locomotive. This leaves a certain amount of weight, in many cases, to be taken out of other parts, with the result that the designer scans all points where he can safely make a reduction.

In one case a systematic study of a design was made. As a result we found that 2500 lb. could be taken out without impairing the efficiency of the details or of the locomotive as a whole.

Cast steel cylinders offer a possible means of weight reduction, although they have not been used to any considerable extent. For large size locomotives, they would probably reduce the weight of the cylinders 3500 lb. per pair. There are a number of details, such as sand boxes, boiler fronts, etc., where material reductions can be made. We have been able to do much in the way of steel shakes for sand boxes. Wood cabs and wooden running boards can be used but there is a greater desirability in using steel.

Another thing is the question of changing steel worked out standards owing to new devices. I have under consideration the question of reducing the size of the cab. We have been able to reduce them from 84 in. and 90 in. down to 6 feet. The Pennsylvania has started on this line and we may see quite a little done in this way in the future.

H. V. Wille in discussing use of high-grade alloy steels to reduce weight brought out the fact that many railroad metallurgists do not consider that the possibilities of high-grade carbon steel have been utilized to the fullest extent by designers. This is no doubt due to the fact that designers and metallurgists view the properties of steel from entirely different points. The metallurgist wishes a steel of great ductility with a good elongation and reduction of area, or in other words, a steel that will readily flow under limiting loads; whereas the designer desires a stiff steel, one of high elastic ratio or a steel that will not readily flow under loads above the elastic limit. The metallurgist therefore specifies a steel with a high elongation and reduction of area and to meet these conditions the manufacturer is compelled to use a steel of medium carbon.

As for possibilities of improvements, a decided reduction in weight as well as the elimination of failures would result from a modification of existing specifications for forgings for the purpose of permitting the use of steel of high tensile strength and elastic limit even at a sacrifice of ductility as measured by the elongation and reduction of area. These views are sustained by the results of an elaborate series of tests conducted by the United States Government at the Watertown Arsenal by Jas. E. Howard, on the endurance of rotating shafts. Enormous increase in endurance following the use of material having high elastic limit and tensile strength was notable and it was shown that carbon steel shaft exhibits as much endurance as 5.6 per cent nickel steel.

When steel forgings were first proposed for use in locomotives, a soft grade of steel was generally employed, the purpose being to secure a steel of similar properties to iron formerly employed.

The use of this material resulted in an unusual number of failures of axles, pins and rods. After studying these failures, Dr. C. B. Dudley, S. M. Vauclain and S. T. Wellman experimented with higher carbon steels. This led to the general adoption of steel of 80,000 tens. str. for locomotive work, with the result that the failures were eliminated and the great superiority of this steel over the softer steels was demonstrated notwithstanding the great difference between the two steels in elongation and contraction of area. This grade of steel is still being universally employed and any changes were for the purpose of increasing the ductility requirements rather than the tensile requirements, thus handicapping the manufacturer in the development of this grade of steel.

If specifications were revised to permit the use of a 0.65 carbon steel there would be but little necessity to employ the expensive alloy steels.

C. D. Young in discussing the above subject called attention to the ordinary annealed carbon steel as used generally for locomotive forgings. The minimum physical properties may be considered as follows: tensile strength, 80,000 lb. per sq. in.; elastic limit, ½ the tensile strength; elongation in 2 in., 22 per cent; reduction of area, 30 per cent.

With properly quenched and tempered carbon steel we may expect an increase in the elastic limit of 30 per cent or more, the elongation remaining the same and the reduction of area increasing about 15 per cent. These are conservative figures and a great deal better elastic limit and tensile strength may be obtained, depending upon the chemical composition of the steel and the heat treatment.

From alloy steels, such as chrome vanadium or chrome nickel, we may expect to obtain the following physical properties after heat treatment: tensile strength, 95,000 lb. per sq. in.; elastic limit, 75,000 lb. per sq. in.; elongation in 2 in., 20 per cent; reduction of area, 50 per cent.

On an average, these alloy steels will show an increase in physical properties over those of annealed carbon steel of 20 per cent or more in tensile strength, 80 per cent or more in elastic limit, with elongation in 2 in. about 9 or 10 per cent less than that of the carbon steel, and the reduction of area of 75 per cent or more greater. These figures are subject to modification on account of variation in the chemical composition of the steel and the heat treatment.

In carbon steel castings approximately the same per cent increases in physical properties as were given for carbon steel forgings may be obtained after proper heat treatment. The experience with alloy steel castings has been too limited to furnish any satisfactory data. Up to the present time the majority of users of heat treated steels seem to have made but little, if any, use of the increased physical properties as determining the fiber stresses used in design, though some of the larger builders of locomotives have made such increases in fiber stresses for both heat-treated carbon and alloy steels. In certain parts where heat treated carbon steel has been used, the fiber stress has been increased about 25 per cent above that used for annealed carbon steel, and in the case of heat-treated alloy steels an increase of as much as 50 per cent has been made. In some cases, depending upon the design and service for which the forging is intended, it is preferable to allow no increase in the fiber stress, but to consider the excess strength of the heat treated material as contributing to increased life in service, or to safety.

Recent practice has indicated that it is desirable, when using heat treated designs, to study carefully the section, so as to avoid abrupt changes, and also in the cases of larger shafts such as axles or crankpins, that they shall be hollow bored in order to provide for better treatment and to relieve shrinkage strains which occur during the quenching process.

While there is no objection to the change of the present standard section, it would seem, with our present knowledge of heat-treated material, that it would be entirely safe to use certain increases in the fiber stresses when designing locomotive parts. As a suggestion as to what could be done in this respect, I have tabled what is recommended for three grades of steel as to working fiber stresses and the minimum ultimate strength and elongation. This has been tabulated for the grades of 0.45 annealed carbon, quenched and tempered 0.52 carbon and quenched and tempered alloy steels.

The results shown in this table seem to indicate that heat-treated carbon and alloy steels will show greater resistance to wear and to the fatigue stresses in service than are shown by annealed carbon steel; and it is our opinion that the increase in resistance to wear is about in proportion to the increase in Brinell hardness which is brought about by the heat treatment.

C. F. Street in a written discussion stated that stokers have not only increased the earning power of existing locomotives but have also removed all limitations, from a fuel quantity standpoint, on the size of locomotives which can be built.

Many instances could be cited of the increase in earning power of existing locomotives. Take the case of a saturated steam locomotive having about 54,000 tractive power and a tonnage rating over a certain division of 4750 tons. Superheaters were applied and the tonnage rating increased to 5000 tons. Stokers were applied and the tonnage rating increased to 5250, then 5500, then 5750 and finally to 6000 tons. In the meantime, the tonnage rating of the shovel-fired superheater locomotive increased to 5500 tons. The increase in the tonnage rating of the shovel-fired locomotives is very interesting and brings out strongly one of the indirect advantages of the stoker. It shows very clearly that before stokers were applied the shovel-fired locomotives were not doing anywhere near what they should do, and as soon as the stoker came into use, it increased the earning power not only of locomotives to which it had been applied but to all others on the division.

Reference to several of the locomotives mentioned in the committee's report brings out the fact that the stoker has removed limitations on the size of locomotives. The mountain types referred to were fitted with stokers when they were built and have always been stoker-fired. A number of other locomotives, notably the most powerful Pacific type as yet built, are now in regular operation and would never have been contemplated without a stoker. As high as 8 tons per hour have been put in a firebox with an existing machine and without working it to capacity. There is no reason why any desired quantity of coal cannot be fired by the use of a stoker and this limitation is entirely removed in connection with the designing of new locomotives.

The stoker, as yet, has not progressed far enough

to bring forth definite figures regarding its efficiency. Wherever it has been introduced the question of increased tonnage has been more important than that of fuel economy. This is only a temporary condition and as more stokers are applied the question of fuel economy will become more important. We have, however, gone far enough to determine definitely two points: First, the stoker will burn a much cheaper grade of coal than it is possible to use with hand firing; second, it will give a more uniform rate of fuel consumption on locomotives performing the same service.

It is a well-known fact that there is a difference of from 25 to 50 per cent in the amount of coal burned by different firemen for performing the same work. The stoker is eliminating this great variation and making the results more uniform.

There are today very few shovel-fired locomotives in this country having a maximum tractive power of 50,000 lb., or over, which are being worked to their full capacity. Wherever stokers have been applied the earning power of the locomotives has been increased from 10 to 20 per cent. There is no instance where stoker-fired and shovel-fired locomotives are being operated under identical conditions. The stoker-fired locomotives are in every case, hauling increased tonnage, using a cheaper fuel or working at higher speeds.

E. A. Averill remarked that in a report of a test on a large locomotive at the Altoona test plant it is stated that the results indicate that the capacity of the boiler was limited by the ability to burn the coal on the grates and not by any failure of the heating surface to absorb the heat supplied. While in this case the limit was marked by the impossibility of supplying sufficient air through the grates to burn the fuel properly, there are a reasonably large number of locomotives operating in this country today which are running at less than full boiler capacity because of the physical inability of the fireman to supply the amount of fuel that can be burned.

He said he had selected at random 10 classes of locomotives built during the past three years which are typical of the general size and capacity of all the larger freight locomotives built in that time. When delivering the power that each of these locomotives is easily capable of, if in good condition, it was seen that they required from 4900 to over 8000 lb. of good quality coal an hour. They are actually getting from 4500 to 5000 lb. an hour, and handling trains of a proportional size.

A number of locomotives like these, all of the same class, and operating on the same division, will have a tonnage rating in proportion to the ability of the average poorest fireman that is assigned to them rather than to the average best fireman. While there may be a few firemen on the division who are capable of developing the full boiler capacity, the group of engines as a whole may be daily working much below their actual capacity.

The acceptance of the opportunity to supply the desired quantity of coal at all times to these locomotives that is offered by the stoker, will have the same practical effect on operating expense as would a new order of more efficient, larger locomotives.

A reduction in the cost of conducting transportation follows this increased locomotive capacity in a number of the principal items when presented on a ton-mile basis. The stoker itself offers an opportunity for further savings particularly in the cost of fuel, reduced claims for damage or accident and the recruiting of men of higher calibre for locomotive service.

An instance of the possible savings in the cost of conducting transportation, through increased locomotive capacity following the application of a stoker, is found on a certain division where 10 tonnage trains are sent one way over the road each day with hand-fired locomotives. Application of stokers has permitted an increase of over 11 per cent in the tonnage of a train. The return movement is largely empties. The application of stokers will give a direct saving from wages and train supplies alone, of about $100 per engine a month on this division. If advantage is taken of the increased capacity of the division for tonnage without the addition of more locomotives, the saving will be considerably larger.

Naturally one of the first features to be investigated by a railroad considering the application of stokers, is the cost of maintenance. In general, the machine of any kind with the fewest parts, if they are properly designed, will cost the least for maintenance, inspection or repairs. During the past year and a half there has been a distinct advance made in connection with the simplification of the stoker apparatus. The latest type of locomotive stoker consists of a comparatively few, strong, heavy parts and a very few wearing surfaces.

There has been much discussion of the amount of coal consumed on stoker fired locomotives. In some cases they do burn more coal per trip and the mistake of making the comparison on pounds of coal consumed per 1000 ton miles has led to the deception of some investigators. Accurate tests permitting the comparison of shovel and stoker firing to be made on the basis of pounds of coal per indicated horsepower, have shown widely varying results with different designs of stokers. Some carefully conducted evaporative tests with the most recent design of stoker are very encouraging in this particular. These tests were made with the locomotive in regular service. Comparing the average of five hand-fired runs and four stoker-fired runs on the basis of actual pounds of water evaporated per 1,000,000 B.t.u. supplied, the stoker gave an increase of nearly 7½ per cent. In another case the increase in evaporation with the stoker was nearly 12 per cent. From these figures, as well as observations in regular daily service, it would appear that some saving in coal can be expected from this stoker. These tests were made with run-of-mine coal.

A stoker should successfully handle the coal in any condition in which it may be put on the tender. It should make no difference if it be all dust or clean lumps of larger size; soaking wet, slightly damp or bone dry. It should take the coal as it finds it the same as a fireman does. The development of stokers in this direction during the past year or two has been particularly satisfactory and ordinary run-of-mine coal is now being used with complete success.

The use of lower and cheaper grades of coal is quite general on the stoker locomotives of a number of roads which report a net saving from the practice.

Calculations that have been made of the movement of the gases in a firebox equipped with a brick arch, show that velocities of 265 ft. a second will be present over the end of the arch when burning 6000 lb. of coal an hour on 70 sq. ft. of grate area. The velocity decreases as the fire bed

is approached and at a point 2 ft. above the grate the gases have an average velocity of about 33 ft. a second. This clearly indicates the importance of injecting the fuel charge as low down in the firebox as possible to reduce the loss by fine coal passing through the flues partially burned. The more recent development in stokers has given this feature the attention it deserves.

Opportunities for economy in connection with the reduction in damage claims follow the better lookout from the locomotive by the fireman being left free to watch signals, crossings and operation of the machinery on the left side. One of the essentials in this connection is noiseless operation. The stoker should not prevent free conversation across the cab nor make any noise that can be heard when the locomotive is running. The development of the past year or two has shown a wonderful improvement in this particular and stokers are now being applied which are essentially noiseless in their operation.

The stoker should be 100 per cent efficient; it should do all the firing, handle all the coal from the tender with the minimum attention and not require alteration of the distributing means after it is once properly adjusted. The fireman should be free to attend to the duties mentioned above and should be able to control the stoker operation from a position on the seat box.

It is well established in manual firing that small quantities of coal fed frequently and distributed by the " cross fire " method gives the most perfect combustion. The stoker should follow this method but perform the operation more exactly than it can be done by hand.

Another feature of improvement in the most recent of the scatter type stokers is the absence of any part of the stoker on the boiler head or in the cab. Stokers are now being applied which show practically nothing in the cab and thus allow the best arrangement of the many instruments and appliances required on a modern locomotive. This also permits the proper inspection of all the staybolts and their renewal if necessary without the removal of any part of the stoker.

J. E. Muhlfeld in a written discussion stated that the available energy in superheated steam, and the necessity for economy in first cost and for operation will cause the self-contained steam locomotive to remain for a long time the principal motive power for moving heavy tonnage trains long distances. For this reason, the next few years will probably see it substantially improved through the development of Mallet articulated types, superheating, compounding, feedwater heating and pumping, boiler circulation, valve motion gear, reciprocating and revolving parts, combustion, automatic stoking of pulverized fuels and standardization.

G. R. Henderson pointed out that 15 or 20 years ago it was thought that we had reached the limit of size and capacity in locomotives. Shortly afterwards we had some gain in compounding but we had large locomotives giving only from 1000 to 1500 h.p., whereas the size would have led us to think that we could get double that power.

Superheaters, coal pushers, firedoor openers, etc., have all helped to increase the capacity of the locomotive. In a few years we will very probably have largely extended the use of powdered coal. The present limitations of height and width will not differ to a marked degree but the length can be increased without any special alterations except for turn tables and things of that sort where we can easily increase the length.

Our boilers can be increased in length, and there comes in Mr. McFarland's idea of an exhaust fan at the front end to give the necessary draft in the firebox. Powdered coal will help a great deal in assisting in lengthening the firebox and giving a greater amount of evaporative surface.

If we consider the present limitations of drawbar strength, length of siding, and legislative restrictions, I think by this lengthening it is possible to build a locomotive from 250,000 to 300,000 lb. tractive power.

J. B. Ennis in a written discussion stated that 25 years ago the largest steam locomotive in service had a total weight of about 154,000 lb. and a tractive power of 34,000 lb. At that time, a locomotive of these proportions represented the improvement of 60 years of effort in this line of steam engineering, and while this advance had been gradual, it was a series of progressive steps leading up to the building of this " largest locomotive in the world." This 60 years of progress had been a period in which the main object seemed to be increased capacity only. Aside from the fact that the number of wheels was increased and the parts were made larger and heavier, a locomotive of this period in its essential details followed closely the established practice of years before. Detail design had been constantly improving, but at that time no general effort had been made toward improvement in the efficiency of the machine. A pound of drawbar pull meant the burning of the same amount of coal as it had a quarter of a century before.

During the past 25 years conditions have materially changed and the demands made on the locomotive have been such that the progress in its development was to be rapid. From 1889 to 1899 the total weight increased from 154,000 lb. to 232,000 lb. and the power in proportion. It was during this period that it was first realized that increase in capacity could not go on so rapidly unless accompanied by some efforts toward economy. The first general step in this direction was the introduction of the compound principle. Various systems were brought out and for years large numbers of these engines were built, many of which gave decided economies in service as well as increase in power. Although the movement to adopt this principle was advocated by many, the simple locomotive was still preferred and gradually increased in weight and power until it was thought by many that the limit of capacity had been reached.

Fifteen years ago, we find instances of locomotives built, where in order to maintain full power for any length of time, the amount of coal burned was so large as to call for considerable activity on the part of the fireman. Perhaps fortunately, stoker designs had not been perfected, although the time could not have been greatly delayed when consideration was to be given to other devices to bring about efficiency.

In Europe, superheating had demonstrated its economies in locomotive service and about ten years ago the first applications were made in this country. For some time its use was very limited, but after it was proven that high temperature superheaters would give increased capacity and great economy in fuel that would not be offset by high

maintenance expense, and that the economy could be obtained in all classes of service, the movement to adopt this principle became widespread. As a result of this improvement, combined with others that followed, we now have passenger and freight locomotives giving at least one-third more power at the drawbar than would have been possible 10 years ago with simple locomotives using saturated steam and consuming the same amount of fuel.

This increase in weight and power continued and the locomotive soon reached a size where it became necessary to consider, in many cases, some other means of feeding the coal than by hand. The mechanical locomotive stoker was demanded and produced. It is no longer an experiment and is capable of delivering all of the coal that the present day locomotive requires.

As examples of the big steam locomotives of to-day, we have simple freight locomotives giving tractive powers 50,000 lb. greater than the maximum of 25 years ago; an experimental articulated locomotive for pushing service designed to give a tractive power of 160,000 lb; articulated locomotives for road or pushing service with tractive powers of 115,000 lb.; the simple pacific type with 46,500 lb. and simple mountain type with 58,000 lb. Individual wheel loads have steadily increased until we have nearly 70,000 lb. weight per pair of drivers. Our locomotives are as high and as wide as clearance limitations will permit, and yet it would be unwise to say that the limit has been reached.

The big steam locomotive of the future will probably not be the locomotive of the past. To-day we can see possibilities toward further refinement in design; further economies that may be obtained so that the locomotive designer is not yet ready to acknowledge that all has been accomplished.

For freight and pushing service on heavy grade, past performances show the adaptability of the articulated compound engine. This design of locomotive is still in the course of development and it will, without doubt, be the generally accepted type for these conditions for some time to come. With the exception of the experimental articulated locomotive already referred to, locomotives recently built for the Virginian Railway are the largest of the type. A few particulars of their performance may be of interest. Designed originally for pushing service on grades of over 2 per cent and normally rated at 115,000 lb. working compound, these engines have proven themselves capable of handling on a grade of 0.6 per cent a train load of 7180 tons, requiring a drawbar pull of approximately 110,000 lb. On lighter grades and at higher speeds over 3000 i.h.p. have been obtained. Work of this magnitude necessitates locomotives of exceptional weight and power, and yet the possibilities of this type have by no means been exhausted. As conditions arise in the future in which more power will be required, the use of the articulated engine can yet be extended.

For freight service on easy grades where the capacity of the articulated engine is not required, we already have exceptionally large locomotives of the 6, 8 and 10 coupled types. Simple cylinders operating at 200 lb. pressure have reached a diameter of 30 in., and in order to transmit this power a main axle 13 in. in diameter has been used. Main crankpins, rods and other details are of enormous size. With the increase in the diameter of cylinders, the cylinder centers have gradually increased and frame centers decreased. This has resulted in higher stresses of parts than those caused by piston thrust only. The weight of revolving and reciprocating parts has reached the point where, in some cases, proper counterbalancing becomes very difficult. It is doubtful whether much more capacity can be obtained in these types if designed along the present lines, and here it would seem that attention could profitably be given to refinement in design and its relation to the careful selection of materials.

Modern passenger locomotives have reached a high development, and yet there is one problem still to be solved that has been recognized for many years—that of the effect on the rail of the vertical unbalanced forces in a two-cylinder engine. At present our largest and most powerful passenger locomotives have two simple cylinders 27 to 29 in. in diameter, giving maximum piston thrusts of approximately 117,000 lb., with static wheel loads higher than ever before and, with few exceptions, reciprocating parts of much greater weight.

The four-cylinder balanced compound was introduced about 10 years ago as a possible solution and for a few years a large number of these locomotives were built. There is no doubt as to the results obtained, as far as balancing was concerned, and yet recently very few have been constructed. Four-cylinder simple locomotives have also been tried out, but in both these types the capacity is limited on account of the available space between the frames, making it practically impossible to provide the power now given by the largest simple two-cylinder engines.

Little consideration has been given to the advantages of the three-cylinder arrangement, although a few locomotives of this type are in successful service today. As compared with the four-cylinder engine, either simple or compound, the three-cylinder type offers, first, the possibility of increased power. With one cylinder located between the frames ample room is provided for a properly designed crank axle and main rod which cannot be arranged for in the four-cylinder type beyond a certain limit. As compared with the two-cylinder engine, the advantages are briefly, a more even turning moment, an ideal counterbalancing condition and the opportunity to furnish maximum power with the minimum destructive effect on the rail. The power obtained in a two-cylinder engine with cylinders 27 in. in diameter and a maximum piston thrust of 117,000 lb. can be obtained in a three-cylinder engine with cylinders 22 in. in diameter and a maximum piston thrust of 78,000 lb. This decrease of 33 per cent in thrust means a corresponding reduction in the individual weights of all of the machinery, particularly the weights of reciprocating parts.

It is true that much progress can yet be made in the two-cylinder engine towards reducing the weights of reciprocating parts by the careful selection of materials and proper design. The three-cylinder engine, however, offers advantages possessed by no other arrangement, and it would seem that for high-speed passenger service, at least, this type is well worth considering for the future.

# JOHN FRITZ MEDAL AWARD

ON Wednesday evening, December 2, the John Fritz Medal Board of Award conferred the John Fritz Medal for Notable Scientific or Industrial Achievement upon Prof. John E. Sweet "for his achievements in machine design and pioneer work in applying sound engineering principles to the construction and developing of the high-speed steam engine."

Very happily this event was arranged to occur during the Annual Meeting of the Society. The exercises were signally successful and thoroughly enjoyed. There was a large audience and a number of distinguished members of the four great national engineering societies were seated on the platform. Gano Dunn, president of the John Fritz Medal Board of Award, acted as presiding officer.


John E. Sweet, Recipient of the John Fritz Medal

### JOHN EDSON SWEET

Dr. Sweet's prominence as a national figure dates from his connection with the Sibley College of Mechanic Arts of Cornell University, in 1873. His connection with this institution lasted only until 1879, and in that brief period he rose from a position of obscurity to one of prominence, which he has ever since maintained. It was a case of the man and the hour. Mechanical engineering as a department of organized education was a new thing. In it there were no precedents, and regarding it there was almost universal skepticism. Its plans, its scope and its aims were unformed even among its friends, and its friends were few. Those who should have been its friends were largely doubters of its practicability, while among educators of the scholastic type it found no sympathy and less support. In its field there were, of necessity, no experienced educators, and perhaps it was best that there were none. The field was fallow, and into it came, almost by accident, the personality of this untried and unknown man.

His work was two-fold; first, that of a teacher, and second, of a pioneer in mechanical construction. As a teacher, the immediate results of his work will necessarily die with his students, but as a pioneer he laid enduring foundations. Previous experience in England had shown him the fundamental importance of the work of Whitworth, which, because of our then happy-go-lucky methods, had found little appreciation on this side of the Atlantic. Combining an appreciation of Whitworth's advanced standards of accuracy with original conceptions of fundamentally correct principles of construction of a kind far surpassing Whitworth's work, he established a school of construction of which the influence has been far-reaching. Along with this went an application of art in design—not the art of ornamentation, but the highest of all, and in engineering work the only true art, that of perfect adaptation to purpose—that has never been surpassed and probably never equalled. The Straight Line Engine was an embodiment of these principles, and from all points of view a perfect illustration of them.

Analysis of a successful teacher's methods is always difficult, and the greater the success the greater the difficulty. There is, perhaps, no field of human endeavor in which individuality has greater scope, as there is certainly none in which the methods of different, though equally successful, men differ more widely. Of Professor Sweet's methods there was little organization and less formality. For their prototype we must go back to the schools of the Greek philosophers, who gathered their students about them and taught by a process which was one of absorption rather than acquisition. Without compulsion, students gravitated to him as pieces of iron to a magnet. With few material aids and resources, and in that wider sense which consists of the training of the faculties and the formation of correct methods of thought and work, no finer example of educational work can be found. Those who came under its influence felt, and still feel, that they enjoyed a precious privilege. As a teacher, Professor Sweet was one of those few and rare, whose pupils became disciples, and to his success there is testimony that is unique—the informal organization of men, most of them beyond the meridian of life, who, calling themselves Professor Sweet's Boys, gather year by year on the occasion of his birthday, and from long distances, for an annual dinner with him at Syracuse. If any similar tribute is paid to another teacher the fact is not known.

Dr. Sweet was born October 21, 1832, at Pompey, N. Y., his mechanical talent being an inheritance through his mother. His introduction to mechanical

work was through his apprenticeship to the carpenter's trade, from which he developed as a builder and architect. In 1862 he went to Europe and for a time worked in England as a mechanical draftsman. Returning in 1864, the peculiar individuality of his work soon began to manifest itself, his most ambitious production of this period being a type-setting machine which is still preserved at Cornell University. Later, he was engaged in bridge building for Howard Soule, from which work he was drafted to the Cornell shop, where his pioneer work in accurate measurements was done. This with other examples of student workmanship was exhibited at the Centennial Exposition, where it attracted world-wide attention. The Straight Line Engine Company, with which his name has been identified, was organized soon after leaving the University. It was his suggestion which led to the organization of The American Society of Mechanical Engineers, of which he was the third President, nominations for previous years having been declined in favor of others whom he—mistakenly and characteristically—considered better fitted for the office. Other honors have been showered upon him, and always, as in the present case, against his protest. The most unselfish and helpful of men, and completely devoid of the spirit of self-seeking, he has found his reward in the unstinted esteem of his fellow men.

## THE EXERCISES OF PRESENTATION

In his opening remarks Mr. Dunn said that the meeting was not so much in honor of Dr. Sweet as in recognition of the things which Dr. Sweet himself has done, which alone can justly do him honor. He then introduced the first speaker of the evening, Dr. James Douglas, past-president of the American Institute of Mining Engineers, who gave an address on the Development of Engineering in the United States.

### ADDRESS OF DR. DOUGLAS

Dr. Douglas spoke particularly of the work of the engineer in the mining industry. The miner has always been more or less of an engineer. The primitive engineer was ingenious, and could install his own hoist and pump and if he had a running stream used the force of falling water to generate power and even compress air. With the introduction of the steam engine, however, came the need of the assistance of the engineer. For three-quarters of a century a very simple type of engine served the purpose; but within the memory of most of us there have followed in quick succession engines of elaborate design to economize steam, railroads, telegraphs and telephone, the dynamo, and electricity, applied to manifold uses. Each branch of engineering required a skilled expert in its application to mining and the engineering staff is now a distinct complement of the mining and metallurgic members of every large organization in this field and are accepted as essential helpmates.

The engineering members of the modern mining and smelting plant outnumber those who direct the primary operations of the enterprise. On the roll of the Copper Queen Company, for instance, omitting the administrative and accounting officers, there are at headquarters a consulting engineer, with several expert mechanical and electrical assistants and draftsmen. Apart from them the mining staff consists of a superintendent, an assistant superintendent, a geologist and three assistants, three chemists, an operating electrician and 10 assistants, a chief mechanical engineer and 13 assistants.

In the smelting department of the same company, apart from the furnace superintendent, his assistant and two understudies, the officers are a mechanical engineer, an electrician and 12 assistants, a chemist and physicist and five chemists engaged in purely experimental work.

At both the mine and the smelter the power is generated in central works distributed by compressed air or electricity to hoist at surface, and underground; to power drills; to trolley lines; light circuits; to all of which more or less expert skill must be directed.

The power utilized at the mines is derived from 411,623,120 cu. ft. of compressed air and 321,539 kw-hr. The power generated at the Douglas Smelting Works is 3339.4 h.p. In mining, therefore, the amount of engineering supervision is out of all proportion to the quantity of power generated.

If we look beyond the metallurgy of the more costly metals whose value is in proportion to their scarcity, the demands upon the skill and energy of the engineer rises rapidly. On the average 83 tons of iron are consumed for one ton of copper, and when one traces the iron from the mine through the monstrously large smelting and rolling mills, where the metallurgist is almost obscured by the engineer, over the railroads to the stupendous buildings, where the iron is to be buried in concrete and brick to the amount of 10,000 to 30,000 tons per structure, one appreciates how intimate must be the alliance between the engineer and the miner and metallurgist.

Dr. Douglas referred to the metallurgical element in mining and metallurgical work. He came to the conclusion that the last person to select in this capacity is the expert, for if he is a trained mechanical engineer, mechanical devices will be too attractive; or if an electrical engineer, he will be emphatically an electrician, and so on. The manager should have instead just as much and as little knowledge of each branch as will enable him to select competent men and decide when a proposition is laid before him, presenting alternative methods, whose argument is most conclusive.

In respect to the future, in the light of the con-

servation of our resources, the speaker said that although it is not very difficult to estimate the date of the exhaustion of our ores at the present proportionate rate of increase, we nevertheless appear to be more worried about the consumption of our forests, which can be restored, than over the almost reckless consumption of iron, which rusts and vanishes. On the other hand, in respect to coal, we may be confident that long before the supply is exhausted, power, heat and light, and all that coal confers upon mankind will be derived from the transformation of other natural forces through the accomplishments of the physicists and the engineers, and that humanity will be relieved from the grimy work of delving underground for fuel.

ADDRESS BY DR. STRATTON

Following Dr. Douglas, Dr. W. S. Stratton, Director of the Bureau of Standards, Washington, D. C., addressed the meeting on The Relation of Standards to the Development of Engineering.

THE JOHN FRITZ MEDAL IS A DISTINCTION FOR NOTABLE SCIENTIFIC OR INDUSTRIAL ACHIEVEMENT CONFERRED FROM TIME TO TIME IN MEMORY OF THE GREAT ENGINEERING PIONEER, JOHN FRITZ, AND THE AWARD OF THE MEDAL IS MADE BY A PERMANENT BOARD OF AWARD COMPOSED OF FOUR DISTINGUISHED MEMBERS FROM EACH OF THE FOUR GREAT NATIONAL ENGINEERING SOCIETIES

He said that no greater tribute can be paid the honored guest of the evening than to say that he was a member of the small group of men who, in laying the foundation of modern engineering practice, introduced into it precision measurements. They made possible and introduced the interchangeable system of manufacturing, one of the principal factors in our country's industrial development.

For precision measurements are required certain standards which belong to the general group of Standards of Measurement. Other groups of standards may be roughly classed as Standard Values of Constants; Standards of Quality; Standards of Mechanical Performance; and perhaps Standards of Shape and Form. The government is interested in each of these but for widely different reasons. In some cases, principally standards of measurement, it is from the standpoint of authority vested in it by the Constitution and absolutely necessary for the sake of uniformity in the measurements upon which all other forms of standardization depend. In other cases, it is interested in the standards and measurements used in the collection of duties and revenues, in the development and conservation of our natural resources, in the promotion of commerce and industry, and in placing its own work on an economical and business-like basis. To care for these interests, Congress established the Bureau of Standards in 1901. The Bureau does not assume an authoritative position except as to standards of measurement; in the other cases, its capacity is that of assistance in their establishment and advisory as to their use.

Standard values of constants enter into physical quantities, and are used in every branch of scientific work or industry. The amount of heat required to change a pound of water into steam under normal conditions, and the relation between heat and mechanical energy, are two important physical constants; their values are used in practically every computation in connection with the designing of steam engines and boilers, the tests of their efficiencies or the measurements of their output. The amount of heat required to turn liquid ammonia into vapor or the amount required to melt a pound of ice are constants equally important in the refrigerating industries.

No one institution can accomplish more than a small part of the experimental work in this field. It is being done in government laboratories and scientific institutions throughout the world, hence the government is interested not only in the production of such data, but in gathering them together from all sources and in making them quickly available to the public as well as acting in an advisory capacity as to their use.

In considering standards of quality, it may be found

that a certain kind of steel, a cement, a paint, an oil, or a paper or cloth, is found by use to be good or poor. The questions then arise, what are the physical or chemical properties, or the particular combination of elements which make it of good or poor quality; how are its properties to be measured or its constituents determined. These are questions for the laboratory to answer and again involve scientific investigations of the most difficult sort.

The government is interested in this class of standards, partly from selfish motives in connection with its own purchases and construction, but principally from the broad standpoint of the public interest generally, just as it is interested in increasing the productiveness of the soil or in developing our mineral resources. The economical and proper use of materials is an exceedingly important factor in the great problem of their conservation.

The actual testing of materials by the government through its Bureau of Standards, to ascertain whether or not they comply with specifications, is confined almost exclusively to government purchases, but in making these tests, in which the Bureau has had the hearty coöperation of practically all the departments of the government service, it is compelled to make many investigations concerning the properties of materials, their specification and measurement. While this work is of great value in placing government purchases on a correct basis, the results of the investigations as to the properties of materials and the information gained in testing government supplies, is even more important to the general public.

In respect to standards of performance, the performance of an engine or boiler, a pump, an electrical generator or motor, a weighing device, or a telescope, can usually be measured, but the quantities to be measured and the method used must be specified correctly, and understood by all concerned in the construction, purchase, or use of such apparatus. To do this properly involves the use of standards of measurement, standard values of constants, and standards of quality. The Bureau of Standards does not attempt to cover this field completely, but only those cases where there is a lack of definite scientific data upon which to base specifications, and to the more important classes of apparatus.

Again, the Bureau's activities in this field have been principally in connection with government purchases of apparatus and machinery. Government purchases of equipment, however, are not greatly different from those of the public. Whenever the Bureau makes a scientific investigation or secures such information from other sources for the purpose of the improvement of specifications, it is given to the public in the form of suitable publications. The value of this from the standpoint of the public is even greater than that in connection with government purchases, important as the latter is. In other words, the needs of the public and the government service are precisely the same as far as standards or specifications are concerned, whether it be standards of measurement, quality or performance.

Many questions of disagreement between public officials and utility companies as to standards are referred to the Bureau for advice or adjustment. There is a great need for unbiased and reliable information pertaining to the standards entering into the regulation and sale of the services of public utilities. A striking illustration is to be found in the various state regulations pertaining to locomotive headlights. Some regulations require that headlights shall not be less than 1500 candlepower when measured without a reflector; others specify 10,000 candlepower measured with a reflector. Some states require 300 watts at the arc, while others require that an object the size of a man shall be distinctly seen at a specified distance (they do not state the color of the object), and one state specifies the size of the reflector. There are plenty of such cases.

Some of these regulations are almost as absurd as the law proposed by a Western legislator to make the ratio between the circumference and diameter of a circle the whole number three; or another who, when told that the law of supply and demand interfered with some proposition in which he was interested, introduced a resolution repealing that law.

The Bureau's investigations in connection with the distribution of high potential electric currents, the mitigation of electrolysis, the fire-resisting properties of materials, the standards involved in the regulation of gas service, and the causes of failure of railway materials, are all examples of investigations that are being carried on by the Bureau with a view to ascertaining the fundamental facts needed in making public utility regulation sensible and fair. No doubt the question has already arisen in your minds as to whether this work competes or interferes with that of the engineer; on the contrary, these investigations are for the purpose of ascertaining the very information the engineer needs. The Bureau prefers to work through the engineer. Whenever it comes in direct contact with public officials in such matters, the Bureau encourages the employment of competent engineering services. There are many cases in which it would be far better for those concerned to employ more technical and less legal advice. The Bureau's coöperation with engineers and manufacturers is another important phase of its work.

The value of such minute measurings is sometimes questioned, but they are necessary for the detection of laws or measure constants, which will make it possible to make accurate measurements with even the accuracy required in industrial processes. In the past three or four years one of the Bureau's experts has been engaged in perfecting the instruments used in measuring total radiation, in order that he might determine

among other things the radiation constants with sufficient accuracy for use in the industrial measurement of high temperatures. Recently one of these instruments was used successfully at the Lick Observatory to measure the radiation from stars as faint as the seventh magnitude, or, in popular terms, equivalent to the detection of the radiation from a candle flame fifty miles away.

PRESENTATION ADDRESS

John R. Freeman then spoke on behalf of the Board of Award. He touched in his remarks on the life of John Fritz, saying that he left the art of iron making better than he found it and furnished an example which must be an inspiration to all. The John Fritz Medal was founded on Mr. Fritz's eightieth birthday. The principal rules for its award, as adopted, are that it shall be given for notable scientific or industrial achievement, after consideration by the Board of Award for one year. The Board itself is composed of sixteen members, chosen in equal numbers from the four national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

Eight awards of the medal have been made: in 1905 to Lord Kelvin; in 1906 to George Westinghouse; in 1907 to Alexander Graham Bell; in 1908 to Thomas A. Edison; in 1909 to Charles T. Porter; in 1910 to Alfred Noble; in 1911 to Sir William H. White; in 1912 to Robert W. Hunt.

Mr. Freeman concluded his remarks with the following tribute to John E. Sweet:

To-night the medal is to be bestowed upon the one who more than any other one man now living brought about the forming of The American Society of Mechanical Engineers—to one who years ago as a college professor quickened the life and human interest of many men now no longer young—to one who pioneered in high-speed steam engine building and taught the necessity of precision of workmanship and of opposing stress with metal placed directly along the line of force, if one would double or treble the work to be performed per pound of metal.

Like John Fritz he comes to our meetings as Holmes said, "not 82 years old but 82 years young." His presence brings to mind the words of the poet of Abou Ben Adhem, who begged of the recording angel to at least "Write me as one who loves his fellow men," and who later saw

"The Angel writing in the book of gold
The names of those whom love of God had blest,
And lo, Ben Adhem's name led all the rest."

We bestow the medal upon one whose life has been lighted by a sweet and kindly ideality. Engineering, dealing with hard structural materials, by rigorous theorems, may seem to some to give small place for ideality. Kipling gives a glimpse of the other side, in McAndrews' Hymn.

Poets and painters have hardly excelled in ideality our great engineers working for the good of mankind: for example, Westinghouse dreaming of safer transportation and the manufacture and distribution of power for the service of man: Edison in bringing music to the humblest home; Brashear, Swasey and Warner working in their machine shops have brought the precision of machinery, by application in astronomy, to uplift the soul of man; Leland in that kindliness of heart and love of good workmanship which leads him not only to build the best he knows, and to prize good tools as pictures in steel, but also to gladly help his competitors; Taylor, not always understood, working to improve the understanding between labor and capital, by striving always to bring the workman to higher usefulness; and Hiram F. Mills devoting thirty of the best years of his life without thought of compensation, and as an act of religion, to found the profession of engineer of public health. This kind of man is also illustrated in Alexander Lyman Holley, Hoadley, Trautwine, Loammi Baldwin whose wonderful library of ninety years ago marks the idealism of the "father of Civil Engineering in America," also by Crozier, Hartness, and a hundred others whom we cannot now particularize.

And to this noble army of idealists belongs the friend whose faithful work we commemorate to-night, the manufacturer, who chiseled in stone over the doorway of his works, "Visitors always welcome."

The meeting closed with the formal presentation of the medal by Gano Dunn "to John Edson Sweet, ripe in years, ripe in honors and ripe in the respect and affection of the whole engineering profession."

# DISCUSSION OF THE BOILER REPORT

The importance of the problem that has arisen in the formulation of the report of the Boiler Specifications Committee was again emphasized by the attention that was given to the discussion of the Progress Report (fourth printing) that was issued by the Committee before the Annual Meeting. The report was brought up for discussion at the regular business meeting of the Society at the Wednesday morning session, December 2, and monopolized the remainder of that session until adjournment at 1 p.m. The discussion was adjourned to a separate session in the afternoon and after that to an evening session. On the next day the discussion was continued all day, and was concluded with a five-hour session on Friday, December 4, making a total of six separate sessions, aggregating 20 hours of continuous meeting devoted exclusively to the discussion of the Boiler Code and the work of the Boiler Committee.

At the first session, the business meeting of Wednesday morning, the report of the Committee was brought up in open meeting in accordance with the regular procedure of the Society of discussing all important matters in preliminary form before their final presentation. John A. Stevens, Chairman of the Boiler Specifications Committee, opened the subject by a short address. He called attention briefly to the need for the Boiler Code which the Committee is at work upon and outlined the development of the work up to the present time and the methods that had been provided for all who had further suggestions or criticism of the report. He urged them to submit any suggestions to the Committee at this meeting and in that way to coöperate in facilitating the production of the final report—a matter of the greatest urgency at the present time in view of the need for a definite code which will permit the standardization of boiler work in all parts of the country.

In opening the discussion the President ruled that consideration should be given to the details of the Construction Code only, each subject involved and each paragraph to be taken up serially throughout the book, wherever discussion might be offered. This ruling brought objections from some members, however, and contrary to the proposed procedure, the President entertained a discussion of the general considerations of the report as a whole. A limited amount of unfavorable criticism was made by some who raised objections to the method of procedure carried out by the Committee and by others who objected to the general proposition involved in the Committee's work in so far as it involves proposal of legislation. Considerable discussion followed this, in which the great majority favored the general plan and commended the Committee in its work. Several attempts were made to resume the proposed plan of discussion of the report paragraph by paragraph, but there was no concerted effort made to do this until after a motion to discuss the report as a whole, was voted upon. This gave those who were not in sympathy with the purpose of the Committee's work an opportunity to express their opinions and a vigorous argument as to the merits of the form of code proposed, its effect upon the boiler industry, its advisability and desirability, etc., followed. Finally, a strong attempt was made to bring a motion before the meeting that would test out the points of advisability of continuation of the Committee's work, but the motion was curbed by numerous amendments and was finally delayed by the adournment for the noon recess.

The meeting reconvened at 2 p.m., at which H. G. Stott, Vice-President of the Society, presided. The motion that was before the meeting before it adjourned was withdrawn, and the discussion of the Progress Report began as had at first been planned. It began with page 27 and was continued with careful detailed attention to each paragraph. The criticisms ranged from minor points of punctuation or grammatical arrangement to questions of correctness of the rulings, consistency of the various requirements, and other items of engineering significance. For example, the safety valve requirements which had been approved at a conference of safety valve manufacturers in coöperation with the Boiler Committee and had been considered an important advance in this direction, were not well received by practical men; they were strongly criticized by those who had had actual experience in inspecting boilers, on the ground that they were too complicated and cumbersome for convenient use and also because the method of basing the steam producing capacity on the heating value of the coal would in certain cases require larger safety valves to be applied if boilers were to be moved to states where different fuels would be encountered. The criticism on the modified requirements of this section was so strong that it was decided to refer the entire problem back to the safety valve conference, at which the requirements were proposed.

The remainder of Part I of the Rules for Construction were passed through with a fair rate of progress, detailed attention being given to such questions as fusible plugs, steam and feed piping connections, water column connections, etc., but the argument on the validity of the Tables of Joint Efficiencies was delayed until later. The second session was then concluded with a discussion of Paragraphs 84 and 85 on page 188, relating to the question of welded joints in shells. This resulted in suggestions for slight modifications in wording.

The third session, Wednesday evening, began with a general discussion of the material specifications that

comprised pages 189 to 212 of Part II. Efforts have been made to bring these specifications into complete harmony with those of the American Society for Testing Materials. It appears, however, that the specifications in their present form, are acceptable to that Society, but where there are minor differences present, it is not unlikely that modifications may be made in the American Society of Testing Materials specifications so that they will agree with this group in all particulars.

It was shown, however, that the group of specifications in the Progress Report should be amplified by the addition of further specifications to cover iron rivets, staybolt steel and bar iron and bar steel. This matter was referred to the committee representatives of the steel manufacturers, with instructions to select specifications from the American Society of Testing Materials standards which would cover these requirements. Considerable discussion ensued relative to the form which these specifications should take and the proposed modifications, but no definite action was taken. The new tube specification which was the result of the first complete conference of boiler tube manufacturers in America was favorably commented upon.

The material requirements of the Code were then discussed and extended consideration was given to the matter of the quality of boiler steel specified for the various portions of boilers. This important part of the Code was discussed here more thoroughly than it had been in any other conference or hearing that had been held by the Committee. The result was a complete modification of this section and a final settlement of the question in such a manner as to satisfy entirely the various associations and interests involved. In general, the ruling now stands that furnaces, shells, combustion chambers, or any part of boilers under pressure and exposed to the products of combustion, are to be made of the firebox grade of steel. The other requirements were also revised into better form and made complete by additions to cover a number of other materials used in boiler construction.

The fourth session, on Thursday morning, was devoted to continued discussion of the Rules for Construction section, from page 215 to the end of the Code. In this section, such topics as maximum allowable pressure, efficiency of ligament, staying of heads, dished heads, staybolts and other subjects of kindred importance were considered in great detail, and in the course of the discussion, many minor differences were brought up and argued to satisfactory conclusions. Among these was the case of the lap seam for boilers, which, while manifestly unsuitable for power boilers, was amply strong and offered unmistakable advantages for heating boilers. The result of this discussion was the suggestion that the requirements for heating boilers be segregated in a section entirely distinct from the power boiler rules, so that the particular requirements of this class of boilers can be adequately treated. This matter was referred to a representative committee of heating boiler manufacturers for further study.

The various requirements that tended to limit the sizes of boilers or to enforce unnecessary hardships on manufacturers, received careful attention. The lengths of plates permitted in horizontal return tubular boilers, and the question of lap joints on domes, were decided upon with slight modifications. These were of decided advantage to the manufacturers of small boilers. The clause limiting the length of longitudinal joints was stricken out and that referring to the process of forming butt straps radically modified. Some discussion was given to forms of expression, used in connection with this section of the rules, and many suggestions were made to obviate the possibility of ambiguity in the various rules.

In the afternoon session on Thursday, a variation in procedure was admitted for the convenience of certain members who found it necessary to leave the city that night and who wished to discuss the Recommendations on page 255. Arguments were offered against Paragraph 1 on that page, for the reason that it would limit the size of horizontal return tubular boilers below what is considered by some as good practice. After an extended expression of views, a revision of this paragraph was agreed upon which seemed to relieve the difficulties, to obviate which this paragraph had been drawn.

Following this, some discussion was participated in as to the advisability of the so-called Recommendations Section of the Code, which has been omitted in the Massachusetts Code. The chairman of the Committee explained at great length the purpose and advantages of such a section, and pointed out how better practice might thus be influenced by the moral effect of such Recommendations, which would not, however, have the injurious effect of enforcing hardships upon those for whom they were not intended. As a result some further corrections were made and Paragraph 12 was shown to be of such importance as to warrant its transfer to the main body of the Rules, but no further suggestions were received.

After this, the attention of the meeting was again given to the Rules, beginning at Paragraph 150, page 224 to page 245. The subjects taken up included staybolts, staying heads of boilers and segments of heads, riveting, calking, manholes, settings, valves, feed and blow-off piping, and the provisions for non-standard and second-hand boilers. Many of these points were extensively discussed and some changes were agreed upon for the improvement of the rules in their practical application.

At the sixth and closing session, Friday morning, December 4, at which Vice-President I. E. Moultrop presided, a few points were taken up which had been passed over rather hurriedly in the previous session, particularly in connection with feed piping, point of entrance of feed water to boiler, etc. The requirement

calling for a stop cock between the check valve and the boiler proved very objectionable to some, and there was an extended debate on the question and a vote of the meeting was necessary to settle it. The question of blow-off piping was taken up again and then steam piping, water columns and their connections to the boilers, and the factors of safety of non-standard and second-hand boilers. It was voted that the questions of factor of safety and age limit be referred to a committee consisting of Prof. A. M. Greene, Jr., chairman, Prof. Wm. Kent, Frederick Sargent, F. H. Clark, Thos. E. Durban and H. G. Stott. Another action of importance was a resolution authorizing the transfer of the entire section at the back of the Progress Report referring to stays and furnaces, pages 259 to 267, to the body of the Code, starting on page 233.

The final work of the session was in connection with the matter of the advisability of retaining the tables of efficiencies of riveted joints. There was heated argument which extended to the origin of the tables, the reasons for including them, their practical value, etc. A motion was then made to the effect that a new set of tables should be prepared, using the tensile strength of 55,000 lb. only and the new revised shearing strength values for the rivets. This was put to a vote and carried. Various other details of the proposed modifications in the tables were discussed and settled by vote, and a committee was appointed to redraft the tables.

The final action of the session was the discussion of the policy of procedure in further revision of the report, in which a strong sentiment developed for the elimination of the features of laws and legislation from the report. This seemed to be necessary to bring the Code into acceptable shape for several of the bodies interested in its promulgation. A motion was made to express the sentiment of the meeting, which directed that the Code be redrafted so as to eliminate all legislative requirements and concentrate upon technical rulings and engineering features only. Before adjourning, some time was spent in consideration of the matter of the further revision, the receipt of further criticism and suggestions. The Committee made another appeal for constructive assistance which would tend to make the Code the best that could possibly be produced.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

With the present issue, the Engineering Survey enters into the second year of its existence in its present enlarged form, and the Editor takes this opportunity to acknowledge gratefully the many letters of kindly encouragement and useful suggestions received in this connection.

A new system of headings for the articles in the Foreign Review section has been introduced in this issue, the title of the article being prominently printed in the center of the headline, and a brief summary of the article being given in the next paragraph, so as to enable the reader to see at a glance what the article contains. The reference to the source from which the article has been abstracted, has been relegated to the end of the abstract. In view of the fact that of late numerous orders have been received for having articles which are abstracted in the Engineering Survey photographed from the originals in the files of the Library, the number of pages that would have to be paid for if ordered for reproduction, is indicated at the end of the article.

The Library of the Engineering Societies, as part of its work compiles bibliographic references on various engineering subjects. It is proposed, from time to time, to reprint such bibliographies when the abstract of an article covers a matter of sufficiently general interest on which a search is available. This month, such a search is given on the subject of waterproofing concrete.

THIS MONTH'S ARTICLES

Data on the combustion of benzole in internal combustion engines are given from an article describing the work done at the Technical High School at Karlsruhe. The next abstract describes an interesting Pelton turbine installation which is said to use the largest jet so far applied. In the same section there is a description of a water level indicator by which it is possible to discover variations as small as 0.078 in., and which can be read at a distance.

The section on Mechanics contains several abstracts of interest on the experimental determination of the uniformity of running of prime movers; flow of oil in pipes; torsion strength of reinforced concrete beams; application of the principle of Saint-Venant to the solution of problems on beams; the principle of variation in the theory of elasticity.

A description of an improved surface cooler and data on a centrifugal machine for drying sludge are found in the closing sections of the Foreign Review.

Excessively dry air in cold stores is the subject discussed by Wm. D. Sawers before the Cold Storage and Ice Association. Data on Chinese concrete, and on the difference between steel and iron reinforcing elements, hooked bars and straight bars and other data are presented in a report of a committee of the Engineering Society of China.

The application of the counter-current principle to directly fired and waste heat boilers forms the subject of the paper of George H. Gibson before the Engineers' Society of Pennsylvania. The author arrives at some interesting conclusions, on the use of economizers especially, which are at considerable variance with the view usually held.

The testing, and some particulars of construction, of a large reversible rolling mill is described by Karl Nibecker in a paper before the Engineers' Society of Western Pennsylvania. The tests have shown an inordinately large loss of power in accelerating and retarding the engine parts, but a very low loss of power due to friction, and indicates several other features of interest to the engine designer and rolling mill man.

The paper of F. A. Weymouth on typical rail failures describes various causes of rail failures, gives a classification of defects, and discusses the so-called frictionless rail. Another paper dealing with steel structures, in this case ship plates, is that of W. J. B. Wilson, where a remarkable failure of a consignment of such plates is described, and it is shown how unreliable the indication of the usual methods of investigation and testing may prove to be in some cases.

Two papers abstracted from the Journal of the Western Society of Engineers, treat of the characteristic curves of centrifugal pumps, and of permeability tests on gravel concrete.

## FOREIGN REVIEW

### Hydraulics

WATER TURBINES ON THE BORGNE RIVER PLANT.

The article forms part of a series describing water turbines and their governors. In particular, it describes a Pelton turbine delivered by Escher, Wyss & Co., for the Borgne River plant of the Aluminum Industry Co. of Neuhausen. It is remarkable both on account of its size and its design.

The water is delivered to the turbine by pipes 900 m. (2952 ft.) long and 1100 mm. (43.3 in.) average diameter. These pipes are lapwelded by hydrogen flame. The turbines are rated at 7500 h.p., with a maximum output of 8250 h.p. at speeds of 273 to 300 r.p.m. The exciter turbines have an output of 600 h.p. at 800 r.p.m. The turbine is shown in Fig. 1 A. It has a runner of 2.5 m. (98 in.) theoretical diameter and a *single* nozzle out of which, with needle fully withdrawn, issues a jet 0.2 m. (7.8 in.) in diameter. This is the largest jet hitherto applied. Fig. B shows the way the blades are held. Each blade is held by two staggered ring elements and supported against the next blade, so that the bolts have only the purpose of holding the segments together. The runner is made entirely of steel casting. All parts of the turbine which are subject to normal wear are installed in such a manner as to be easily and quickly exchangeable. A steel shaft is supported on two lubricated ring bearings, symmetrically disposed with respect to the center plane, while collars are provided to take up the axial thrust; each bearing has two lubricating rings and an oil circulation pump which sends back to the bearing the oil flowing away from the cooling pipes.

Fig. A indicates the needle nozzle with the needle and its appliances, jet deflector and the mechanism for moving the governor. On the same level with the turbine shaft to the left, at a distance of 2150 mm. (84.6 in.), is located the governor shaft driven by the universal oil pressure regulator. This shaft actuates the entire regulator mechanism. The

needle rod is loaded by the hydraulic pressure on the needle cylinder (220 mm. or 8.6 in. in diameter) as well as by the pressure of the spring which acts on its left, so that the resultant axial force $A$ acts always in the direction from left to right. Opposed to this, there is a resistance which, being transmitted by a rocker arm, comes from the pressure regulator with effective cylinder diameter of 180 mm. (7.08 in.) and located 413 mm. (16.9 in.) above the needle rod. During the opening motions of the needle, this resistance is considerably smaller and the axial force is overcome by the force delivered by the servomotor.

The construction and operation of the governor is evident from Fig. C, where for simplicity's sake, the organs producing the load on the needle rod have been omitted and the servomotor is shown as if acting directly on the main rocker arm of the governor mechanism. The mechanism consists of the main rocker arm *ac* with a rigid axis of rotation *b*;

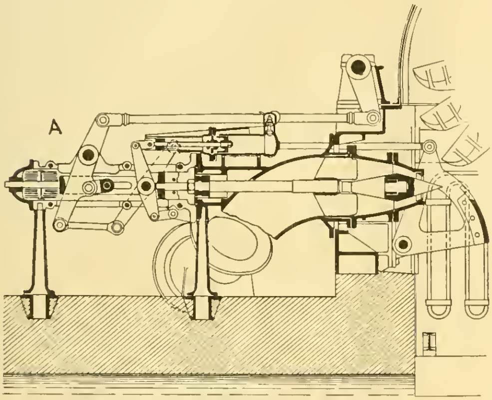


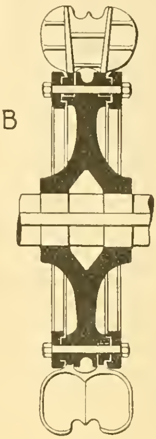

Fig. 1 Large Pelton Turbine and Governor

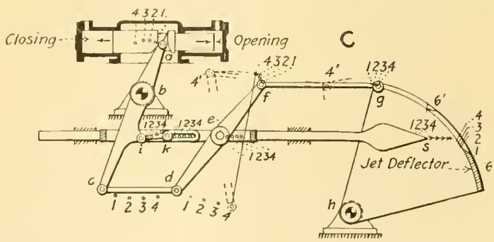
rocker arm *df* has its axis of rotation *e* located on the needle rod and controls the deflection of the support of the jet deflector by means of links *cd* and *fg*. The main rocker arm is connected with the needle rod by the rod *ik*, but the bolt *k* can glide in a slot in the needle rod so that the motion of the needle rod follows directly that of the main rocker arm only when the bolt *k* presses against the left hand end of the link. This will happen always when the pressure regulator is absent or inoperative and therefore, when the resultant axial force $A$ acts on the needle rod. In such a case in positions 0, 1, 2, 3, 4 of the point *a*, the needle automatically takes the corresponding positions and at the same time the edge $\sigma$ of the deflector surface takes the positions indicated by similar figures. To each position of the servomotor, there corresponds a certain position of the needle and a certain position of the deflector, their motion being simultaneous.

The purpose of the mechanism is that in case of sudden and large falling off of load, the jet deflector should be deflected so far that the jet should not strike the wheel; at the same time, the needle starts in the direction of closing the nozzle and this motion continues until the new conditions of load permit corresponding opening of the nozzle. At the same time, this motion of closing should develop with decreasing velocity in order to prevent dangerous pressure surges in the nozzle and piping. Simultaneously with that, the jet deflector should be thrown back again so far that in the normal state of operation established under the new conditions of loading, the edge $\sigma$ of the jet deflector should be outside of the region of the jet, but as near to it as possible. (*Die Wasserturbinen und deren Regulatoren an der Schweizerischen Landesausstellung*, Bern 1914, Professor Franz Prášil, *Schweizerische Bauzeitung*, vol. 64, no. 19, p. 205, November 7, 1914, serial article, not finished. *d.*)

Electric Water Level Indicator With Distant Reading.

A description of an electrical apparatus for reading at a distance water levels in water power plants, such as to per-




mit the observation of very small variations of level to within 2 mm. (0.078 in.). It is operated electrically.

The apparatus described, the details of which are shown in Fig. 2, has been developed by the Siemens & Halske Company, in Germany. It is usually placed in a special little house above a brick-lined shaft, care being taken that there be no turbulent motion of water in the shaft (this is attained by a proper arrangement of piping). The apparatus is provided with a copper float of about 600 mm. (23.6 in.) in diameter. From the float there extends to the indicator a wire rope passed over several rollers, and a counterweight to keep the rope tight. On the axis of the indicator are placed three toothed switch wheels, displaced with respect to each other by a one-third pitch. Each wheel operates a contact lever conductively connected with the in-

dicator apparatus. Therefore three conductors with a grounded return circuit are required, as shown in the sketch. The indicator apparatus is provided with a six-roller motor, consisting of six single-coil circularly disposed electromagnets, the pole shoes of which are directed radially inwards at angles of 60 deg. Each pair of electromagnets is connected in such a manner that the opposite pole shoes should form opposite poles while in the intervening space. There is an easily rotatable axis carrying two soft iron armatures and transmitting its motion to the indicator axis.

If the float causes the switch wheels of the apparatus to rotate, in either direction, the three contacts are moved one after another in such a manner that the next contact is always closed before the contact previously closed is thrown open. In this way, one after another, the three pairs of electromagnets of the indicator are first excited and then left free of current and the armature is forced to rotate in the same sense as the axis operated by the float. A constant current flows through the conductors with a small amperage of only about 0.035 amperes, current being provided by a special battery. Atmospheric discharges have scarcely any influence on the operation of the indicator since at all times there is a pair of electromagnets operated by the line current and the armature tends to remain in any position which it has. A further advantage in the application of open-circuit current lies in the fact that should there occur a break in the conductor or should the battery give out, an alarm circuit will be closed and will at once indicate the trouble. Should it be desired, the indicator can be equipped with a recording apparatus which will show the level of water by a curve on a drum in the usual manner. An apparatus of this type is used in the city works of Gotha, Germany. (*Elektrische Wasserstandsfernmeldeeinrichtung für Feinanzeige*, Georg Schmidt, *Zeits. für gesamte Turbinenwesen*, vol. 11, no. 29, p. 429, October 20, 1914, 3 pp., 4 figs. *d*).

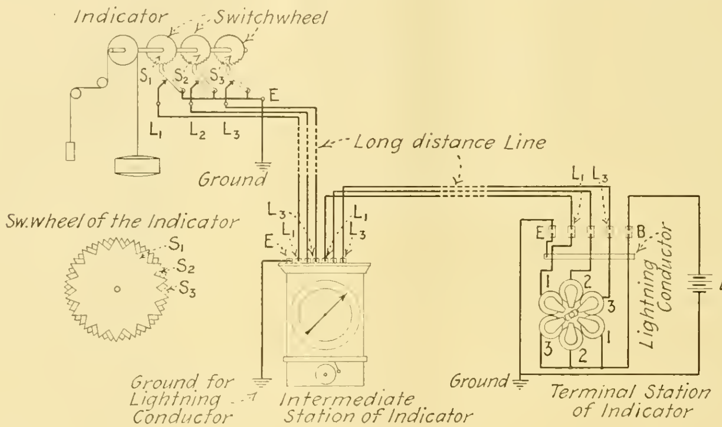



Fig. 2 Water Level Indicator

### Internal-Combustion Engineering

Combustion of Benzole in Internal Combustion Engines.

The article presents tests on the combustion of benzole in internal combustion engines and covers the matters of load compression, ignition and air supply.

The incentive to carry out this experimental investigation was given by tests on heat balance of a 3 h.p. liquid fuel Otto engine, carried out in the mechanical laboratory of the technical high school at Karlsruhe. During these tests, it was found that a fairly considerable amount of energy given to the engine could not be traced and it appeared that this heat loss could be caused only by incomplete combustion of the fuel in the motor as well as conduction and radiation. Even though the constructive part of combustion engines has been well developed and they belong to the class of engines most reliable in their operation, still a good deal remains to be found out with reference to the combustion processes in the motors. It appeared, therefore, of interest to investigate as to how far incomplete combustion contributes to the errors found in the heat balances and how they are affected by the variations in load, compression, ignition and the amount of air of combustion. Products of incomplete combustion are to be looked for in the form of combustible particles in exhaust gases in the condensing water of combustion and in soot deposits in the cylinder. The formation of soot has been very small in all of the tests carried out and its determination therefore could be neglected. The same applies to the case of combustible materials in the water of condensation. It is well-known how few investigations of exhaust gases on engines have been carried out. This may be due to the fact that a chemical investigation of special mechanical problems is too seldom undertaken.

From the investigations of Slaby and Haber, the author proceeds to a brief sketch of the work of Weber, Eugen Meyer and Brook Sewell. More recently, Häuser has determined the heat losses through the exhaust gases of a gas engine in the form of unconsumed material. He used the method of combustion over copper oxide, while Haber and Weber attempted to determine the quantitative combustion of exhaust gases. Häuser considers the method of Haber unreliable since there is not always enough oxygen in the exhaust gases to fully consume the unburned particles. All of the above investigators have found that the amount of

combustible material in the exhaust gases of gas engines does not attain very high values and so far as the influence of load can be considered, it was found that the engines work better at full load.

As regards the kind and amount of combustible particles in the exhaust gases of internal combustion engines using liquid fuel, there are no investigations with the exception of an unpublished thesis by Rudolph Mayer (Karlsruhe, 1909), who has determined volumetrically the percentage of carbon dioxide, oxygen and carbon monoxide, but his data are not claimed to be particularly reliable since his gas samples were not carefully taken average samples and the investigation of the gas was carried out as a side line.

Benzole is not adaptable for use in Diesel engines on account of its endothermic character. It can be only imperfectly changed into oil gas and its compression to the point of self-ignition involves great difficulties. As regards explosion engines, benzole, although it boils at a fairly low temperature (79 deg. cent.), and although the explosion limits of benzole vapor-air mixture are nearly the same as those of gasolene vapor-air mixture, a benzole driven motor has been developed only after considerable trouble, one of the main difficulties having been that of overcoming the tendency of benzole to form soot deposit. It was necessary therefore to investigate the combustion of benzole in engines and it is to this problem that the present experiments have been devoted.

The article describes in some detail the experimental engine and installation. The compression space of the engine could be varied by placing on the piston rod head intermediary pieces so as to increase the compression. The gasification of the benzole was effected by means of a vaporizer illustrated in the original article. It is virtually a needle gasolene vaporizer and does not present anything special in its construction. The Brauer crank mechanism was used to drive the indicator drum.

As regards the collection of exhaust gases, the first attempt was to collect them in a tank filled with water into which they were brought by suction by means of a descending water column. This method proved to be inconvenient on account of the great solubility of the gases in water. Considerable improvement was introduced by determining at the engine the percentage of carbon dioxide which forms the most soluble part of the exhaust gases. To do this, the exhaust gases were passed through two washing bottles, in which, also, the water of combustion carried with the gases was kept back. Then the gases were dried by calcium chloride and anhydrous phosphoric acid, and led into the apparatus for the determination of the carbon dioxide consisting of a Geisler sodium apparatus with KOH 1:1, as well as pipes with calcium chloride and anhydrous phosphoric acid; behind the latter were placed an unweighed protective tube filled with calcium chloride. The gas freed in this way from carbon dioxide was then collected in a gas holder provided with a thermometer, manometer, admission and exit pipes over water.

Later on this method of work, still quite complicated and liable to be a source of errors due to the solubility of gases, was simplified by the use of a mercury gasometer whereby the precision of the analysis was very much enhanced.

The author proceeds to the discussion of the method of gas investigation. Dry exhaust gases consist of carbon monoxide, carbon dioxide, hydrogen, methane or hydrocarbons, oxygen and nitrogen. The analyses made and given in table 1 correspond to three loads at maximum compression. They are, however, only of a preliminary nature. It was found that heavy hydrocarbons are but seldom met with and then only in small quantities consisting mostly of acetylene and sometimes traces of benzole. Only in the gas in a test on 10 kg load, on defective ignition, it was found that because of the defective ignition due to sooted spark plugs, an excessive amount of hydrocarbons was formed; notwithstanding the presence of free oxygen, considerable quantities of acetylene and traces of benzole remained unconsumed.

Of particular interest also, is the presence of methane in the exhaust gases of benzole fired engines. More about this will be said later. It was found, however, that volumetric analyses were not sufficiently precise for the determination of heat losses as unconsumed material in the gas. The author resorted therefore to gravimetric determination in which he could have used three ways: the fractional combustion method of Bunte-Haber-Weber; fractional combustion method over copper oxide and total combustion over copper oxide at red heat. Experiments have shown that because of the small amount of acetylene and benzole present side by side with methane in the exhaust gases, the fractional combustion method is not applicable and a total combustion method over copper oxide was used; the products of incomplete combustion in gas, freed from carbon dioxide and water vapor, were completely burned to carbon dioxide and water over copper oxide at red heat and the amounts thus produced were determined analytically. Although this method gives no information as to the constituents of the gas, it was used here because what was of interest to determine was the heat lost in the form of unconsumed material. The author shows in detail the construction of the apparatus which he used. He also calculated the limit of error and found that it was such as to be entirely negligible in comparison with the amounts of carbon dioxide and water produced.

TABLE 1 EXHAUST GAS ANALYSIS

| | 10 Kg. Load | | 10 Kg. Load, Defective Ignition | 8 Kg. Load | | 4 Kg. Load |
|---|---|---|---|---|---|---|
| $CO_2$ | 12,5 | 8,9 | 6,27 | 12,0 | 8,8 | 8,7 |
| CnHm | .... | .... | 1,56 | .... | .... | 0,3 |
| $O_2$ | 1,0 | 4,1 | 2,40 | 1,2 | 1,2 | 1,0 |
| CO | 4,0 | 6,0 | 10,25 | 7,1 | 10,6 | 11,1 |
| $H_2$ | 1,2 | 2,4 | 2,40 | 2,3 | 4,18 | 5,0 |
| $CH_4$ | 0,2 | 0,24 | 0,5 | 0,25 | 0,43 | 1,4 |
| $N_2$ | 81,1 | 78,36 | 76,62 | 77,15 | 74,79 | 72,5 |

As a basis of all tests on output where a complete heat balance is used, an exact knowledge of the elementary composition and heat of combustion of the fuel must be considered. In the tests, two kinds of commercial benzole were used, and the author describes in detail the data which he obtained from the analyses. It was found that the fuel represented mixtures of various hydrocarbons with boiling points from 69 to 120 deg. cent. (156.2 to 248. deg. fahr.). He determined the upper heat limit of the gas by means of a Berthelot-Mahler bomb calorimeter and found that the

upper limit of benzole No. 1 was 9777 cal. per kg. (17598 B.t.u. per lb.) and benzole No. 2—9902 cal. per kg. (17823 B.t.u. per lb.). The article is not finished. (*Über die Verbrennung von Benzol in Explosionsmotoren,* Dr.-Ing. E. Terres, *Journal für Gasbeleuchtung*, vol. 57, nos. 39 and 40, pp. 893 and 907, September 26 and October 3, 1914, serial article, not finished. *eA*).

**Mechanics**

### Flow of Oil Fuel in Pipes

Data on frictional resistance to flow at varying temperatures of four kinds of oil fuel in pipes of three, four, and five in. diameter.

It is taken from a report of the National Physical Laboratory through *Page's Engineering Weekly.* For the purpose of these tests, special appliances were constructed and include a centrifugal pump with adjustable speed regulation for producing the flow, weighing tanks for measuring the flow, circulating pump and coils for heating and cooling the oil to the required temperatures, and sensitive gages for measuring the fall of pressure along the pipe. In considering the method to be adopted for producing and maintaining a steady rate of flow through the pipes, it was realized that the frictional resistances to be measured were so small that the use of a plunger pump connected directly to the pipes was precluded on account of the fluctuation of pressure that would be produced. Flow under gravity from a large supply tank erected at a height above the laboratory floor sufficient to give the maximum flow required would have been the most satisfactory method, but as the expense of installing this arrangement would have been considerable, it was decided to design a special form of centrifugal pump for effecting the circulation. This was found to work quite satisfactorily, with the exception that in the case of the thickest oil tested, which had a viscosity at 15 deg. cent., which is 3,000 times that of water, circulation could not be produced at temperatures below 22 deg. cent.

As, however, the flow was streamline in character for temperatures far above this value so that the resistance could be predicted from the known values of the coefficient of viscosity, the necessity for observations at low temperatures on this oil was not of great importance, and it was decided to make the low temperature experiments in pipes of small diameter at the conclusion of the research. The pipes used for the experiments were cold drawn steel and about 140 ft. in length. The fall of pressure was taken on a length of 5 ft. situated about 45 ft. from the outlet of the pump, and was measured by a sensitive mercury tilting gage. In this way a pressure of 0.005 in. of water could be detected. (*Page's Engineering Weekly*, vol. 25, no. 530, p. 459, November 6, 1914.)

### Uniformity of Running of Prime Movers and Its Experimental Determination.

Discussion of causes of lack of uniformity in the speed of rotation of prime movers; methods of its experimental determination, and description of apparatus designed for this purpose by the author.

In a paper presented to the Aix-la-Chapelle section of the Verein deutscher Ingenieure, Doctor Bonin, after indicating various causes for the lack of uniformity in the speed of rotation of prime movers, especially machinery driving ships and electric lighting generators, indicated that the construction of experimental devices for determining the uniformity of such machinery is an extremely difficult problem. A pendulum tachograph for the investigation of governing processes did not give sufficiently reliable indications as to the variations of speed during a single revolution, because the pendulum of the indicator itself might get into oscillations which affected the equilibrium of the pendulum. Riehm, in 1912, succeeded in practically limiting these natural oscillations of the pendulum by resorting to the use of an electric eddy current tachometer with an extremely small oscillating mass. Since, however, in order to maintain the oscillating mass as small as it was, he had to use a beam of light as a recording medium and make the record on a photographic plate. The apparatus is not suitable for shop use.

Tests of Mader, who attempted to determine the motion of the engine from single harmonic oscillations by means of an apparatus which he called "undograph," and also the exact law of motion of the engine from the data thus obtained, have been successful in their way, but again the process is far too complicated to be used commercially. Attempts have been made also to record the motion of an engine as a function of time, but when the small scale which can alone be used for practical purposes is employed, the deviations of the curve so obtained from the ideal straight line are so small that no reliable data as to the uniformity of motion of the engine can be secured therefrom.

In the apparatus designed by the author, the pendular paths are recorded directly. A freely rotatable and exactly balanced fly-wheel mass coupled with the engine by a moveable pawl so that it will have the same speed of rotation as the engine and also the same variations of speed is placed on a prolongation of the engine shaft. Should this mass be suddenly freed from its connection with the engine, it will run at the same speed which the engine had at the instant of uncoupling, and further, the speed of rotation of the mass will remain nearly exactly the same while the engine in its rotation will sometimes lead and at other times lag behind the mass. These motions may be recorded on a drum running at uniform speed by means of a light recording pen located between the mass and the engine, the record being such that the abscissae are times and ordinates are the relative paths of the engine with respect to the mass. From this oscillation diagram by some process of differentiation, the relative velocity of the engine with respect to the mass can be determined for each instant, and by this means also the degree of non-uniformity. The oscillation curve in the apparatus proposed is recorded by means of a steel scriber on a specially prepared sheet in such sharp lines that it can be read with great precision. The speaker found it to be so during his tests on a calibrated device and on a gas engine. (*Uber die Gleichförmigkeit des Ganges von Kraftmaschinen und ihre experimentelle Bestimmung,* paper by Dr.-Ing. Bonin before the Aix-la-Chapelle section of the Verein deutscher Ingenieure read on June 17, 1914, published in *Zeits. des Vereines deutscher Ingenieure*, vol. 58, no. 46, p. 1562, November 14, 1914, 1 p. *et.*)

### The Principle of Saint-Venant and the Solution of Problems on Beams.

Application of the Saint Venant principle to the solution of problems on beams.

The abstract is translated from *Beiblätter zu den Annalen der Physik,* as the original publication where the article appeared is not available at the present time. The validity of the principle has not been proved analytically except for particular cases. The author proves it for plain deformations in a beam. The analysis refers to a deformation of a rectangle acted upon on the narrow side by a system of forces of disappearing moment and disappearing resultant (in the plane of the rectangle), while the other three sides of the rectangle are free from stresses. It was found that the stresses in the rectangle, from the initial value, which they have in each of the narrow sides, diminish toward the interior of the rectangle very rapidly and nearly uniformly in accordance with the linear law and at a distance from the narrow side no greater than its own length hardly differ from zero. This holds even in the case where the length of the rectangle is about three times its width. (*Beiblätter zu den Annalen der Physik,* vol. 38, no. 21, p. 1297, and *Wiener Berichte,* vol. 123, pp. 33-51, 1914.)

PRINCIPLE OF VARIATION IN THE THEORY OF ELASTICITY.

The article discusses the application of the principle of variation in the theory of elasticity and its extension to the field of technical statics. It establishes two principles of variation. They are especially applicable to the treatment of lateral flexure of straight bars and bending of straight or curved bars.

If the principle of virtual displacements be applied to elastic bodies and only changes of shape be considered variable, it may be expressed in the following form:

$$\delta_1 [A - \Sigma Pw] = 0$$

where $A$ is the work of change of form, or elastic potential, $P$ the external acting forces, $w$ their displacement along their direction lines, and $\delta_1$ the variation in the change of shape. The author calls this equation the first principle of variation, and sets side by side with it, the second principle of variation which is derived from the principle of virtual displacement, by considering only the forces as variables. It is

$$\delta_2 [B - \Sigma Pw] = 0$$

where $B$ (in accordance with the notation of Engesser), is the supplementary work or work of potential, and $\delta_2$ indicates that the variation refers only to the forces. (*Beiblätter zu den Annalen der Physik,* vol. 38, no. 21, p. 1298, and *Zeits. für Mathematik und Physik,* vol. 63, pp. 174-192, 1914.)

TORSION STRENGTH OF REINFORCED CONCRETE BEAMS.

The article discusses the torsion strength of reinforced concrete beams and shows experimentally how cracks develop when beams are subjected to torsional stresses.

The stressing of reinforced concrete parts in torsion does not occur frequently, but may occur when a beam is stressed normally to the plane of bending. The calculation of torsional stresses even in homogeneous and isotropic materials of construction is only imperfectly possible and then only for rectangular cross-sections. It is natural, therefore, to expect that an exact calculation of stresses in the case of compound bodies would be still more difficult. It is possible to consider the reinforced concrete beams stressed in torsion as divided into two parts, one of which is stressed in bending exclusively (Fig. 3 A). Instead of the moment of torsion $M = Ph$ we may write

$$Q \cdot \frac{2}{3}h,$$

so that

$$Q = \frac{3}{2} P = \frac{3M}{2h}$$

The two parts of the beam may then be considered as stressed in opposite directions by the loads $Q$; the beams would have to be reinforced by steel as shown in Fig. B. This method of calculation would have nothing objectionable in it if the beams were actually divided into two parts before the rupture of these parts and were then stressed in bending. As a matter of fact, however, the rupture of a prism stressed torsionally is entirely different, as shown in

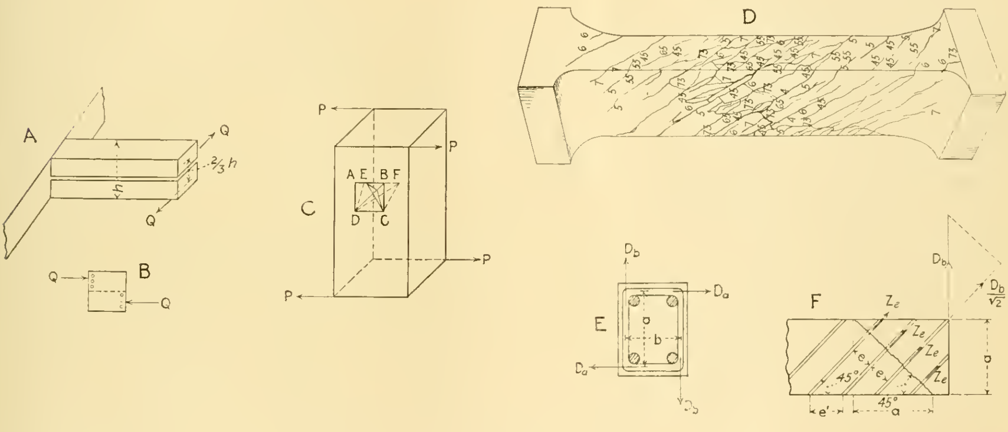



FIG. 3 REINFORCED CONCRETE BEAMS IN TORSION

Fig. D, which represents an actual case. This figure shows that the line of rupture on the faces of the prism run in inclined direction and this in its turn indicates that there are forces acting in torsion normally to these inclined lines, the rise of which can be explained in the following manner: In Fig. C is shown a prism stressed in torsion by two equal and oppositely directed couples. Owing to the change of shape, the original square *abcd* on one of the faces of the prism, is distorted into the rhombus *efcd*, while the diagonal of the square *db* is elongated into the rhombus diagonal *df*. If now the ductility of the material is exceeded, an inclined fissure will be formed normally to the diagonal *df*. In test pieces made of isotropic materials, the formation of fissures can be observed only imperfectly as the conditions of formation of the first fissures bring about a total exhaustion of the strength of the material, and produce rupture. The line of rupture, however, does not always coincide with the line of the fissures as by the appearance of the first fissure, a body of somewhat different dimensions is formed in which the line of rupture has a different location from that of the fissures in the original body. Tests with reinforced concrete prisms were the first to show clearly the processes of formation of fissures through torsion, as in that case the load up to point of rupture could be still considerably increased after the first fissures have appeared.

Fig. D shows clearly the fissures which have been brought about by torsion on the reinforced concrete prism of rectangular cross-section. The prism had six reinforced bars 18 mm. (0.708 in.) in diameter and eight spirals 7 mm. (0.275 in.). Its dimensions are shown in detail in the original article, which contains also another photograph showing the fissures in a prism under torsion making an angle of 45 deg. with the axis of the prism. Tests thus show clearly that on all the faces of a prism in torsion there occur fissures inclined 45 deg. to the axis and that the spirals running normally to these fissures are stressed in torsion. Usually before rupture, the fissures are shifted from the external faces of the prism into the interior in such a manner that tensions which produce these inclined fissures have to be taken up entirely by the inclined steel elements of the spirals. Generally the tensions are uniformly distributed among these steel elements, but as soon as any section of the reinforced elements' limits of elongation has been reached, the tensions begin to be distributed nearly uniformly in the planes of the spiral. For this state of tension, it is possible to calculate the tension in the reinforced elements.

The author proceeds to consider a prism of rectangular cross-section, the sides between the center lines of the spirals being *a.b.*, Fig. E. The moment of torsion is $M$ and it may be considered as if consisting of two couples, each of the forces of these couples acting in a plane of the spiral.

$$M = D_a a + D_b b \quad \ldots\ldots [1]$$

This moment when the limit of elongation of the spiral has been reached produces equal tensions $Z_e$, normal to the direction of the fissures when inclined at 45 deg., Fig. F. The forces $D_a$ and $D_d$ have, each, in the plane of the spirals components $\frac{D_a}{\sqrt{2}}$ or $\frac{D_b}{\sqrt{2}}$ which act in the direction of the spiral elements. If there are in the $a$ plane $\mu$ reinforcing elements and in the $b$ plane $\nu$ reinforcing elements affected by the fissures inclined at 45 deg., then the forces $D_a$ and $D_b$, acting from the outside, are in equilibrium with the external tensile strength strain $Z_e$ if

$$\frac{D_a}{\sqrt{2}} = \mu Z_e; \quad \frac{D_b}{\sqrt{2}} = \nu Z_e \quad \ldots\ldots [2$$

hence

$$D_b : D_a = \mu : \nu = a : b; \quad D_b = \frac{a}{b} D_a \quad \ldots\ldots [3]$$

and from [1] it follows that:

$$D_a = \frac{M}{2a}; \quad D_b = \frac{M}{2b} \quad \ldots\ldots [4]$$

Let us assume that the prism is equipped with $k$ parallel spirals located at equal distances from one another. In a single winding, the spiral has the rise of $2(a + b)$, so that the spirals when measured in the direction of the edge of the prism have, from one another, a distance $e'$ equal to

$$e' = \frac{2\,(a+b)}{k} \quad \ldots\ldots [5]$$

and the minimum distance $e$ equal to

$$e = \frac{e'}{\sqrt{2}} = \frac{\sqrt{2}\,(a+b)}{k} \quad \ldots\ldots [6]$$

The lengths of the fissures inclined to one another to 45 deg. are

$$a' = a\sqrt{2}, \qquad b' = b\sqrt{2}$$

so that the number of the reinforcing elements affected by the fissures is

$$\nu = \frac{a'}{e} = \frac{k\,a}{a+b}, \quad \mu = \frac{b'}{e} = \frac{k\,b}{a+b} \quad \ldots\ldots [7]$$

By using these values in equations [7], [4], and [2], the

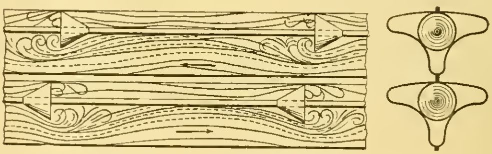


Fig. 4 Surface Cooler Tubes

author obtains the stress in the cross-section $F_e$ of the spiral iron

$$\sigma_e = \frac{M\,(a+b)}{2\sqrt{2}\,F_e\,k\,a\,b} \quad \ldots\ldots [8]$$

which in its turn permits the determining of the number of the spirals $k$.

## Refrigeration

### Improved Surface Cooler.

Description of recent advances of German milking machine design, and among other things, of several types of milk and butter coolers.

The abstract contains a description of such a cooler. It is of the surface cooling type (Fig. 4), and consists of seamless drawn, copper pipes, thickly galvanized, located one over another to a height of 2.5 m. (8.1 ft.) for large coolers. The water flows in countercurrent to the milk. In order to produce further a still better exchange of heat and in in this way save cooling water and especially space, a special round pipe was selected of the peculiar shape shown in the figure, which, within a small space, very materially increased the surface washed by the water. With a pipe so shaped, however, the automatic flow of water would not be as favorable as in the case of round pipes and in order to help

that out, at equal distances all along the pipe, very simple water-displacers have been located, as shown in the figure; this is claimed to assist materially the uniformity of the cooling action and thereby the better utilization of the cooling of the water. (*Die Fortschritte auf dem Gebiete der deutschen Molkereimaschinentechnik,* Ernst Kohl, *Dinglers polytechnisches Journal,* no. 42-43, p. 617, serial article, *d.*)

### Miscellanea

The Drying of Sludge and Its Further Use.

The article describes an apparatus, based on the principle of centrifugal separation, for drying sludge.

It is designed by Hanoverische Maschinenbau. Akt. Ges. vorm. Georg Egestorf in Hanover-Linden, Germany, and the several sections of the apparatus. The mud enters through the centrally located admission pipe *a* from a mud tank placed over the apparatus. Thence it goes into the centrifugal drum *b*, provided with several chambers equipped with screens *c* and inside and outside valves. It is there distributed through the separate chambers when the valve is opened. Through the action of the centrifugal force, the heavier particles of the mud are thrown into the external part of the chamber, while the specifically lighter water is forced out of the mud and flows out through the screens of the chambers into laterally located pipes, whence it is allowed to escape. The space which was formerly taken up by the water is then filled with a new supply of mud so that in a short time, the chambers are filled with mud practically free from water and air dried. Then the inner valve is opened,

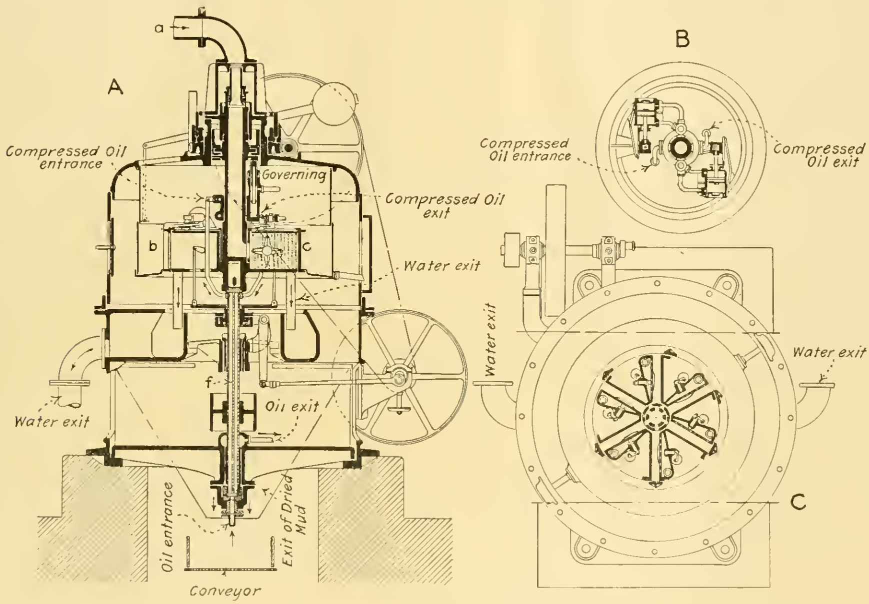



Fig. 5 Centrifugal Sludge Dryer

engineers of the city of Frankfort-am-Main. It has been known for a long time that by centrifugation, the sediment can be reduced to from 4/5 to 6/7 of its original volume, and this fact was placed as the basis of design in the new apparatus to take care of the very large amount of sediment in the Frankfort plant. In Germany, the amount of sewage waters in the cities varies from 100 to 200 l. (26.4 to 52.8 gal.) per day per unit of population in places where no particular causes for its increase are present, but rises to from 300 to 400 l. (79.2 to 105.6 gal.) per day per unit of population where there are extensive dye or laundry works. The sewage has been found to contain from 5 to 10 per cent of solid matter, and from 95 to 90 per cent of water.

The working process in the centrifugal separator is divided into two periods. In the first period, the sediment entering into the apparatus is dried by centrifugal separation of the water; in the second period, the solid particles remaining in the machine are eliminated. Fig. 5 A, B, C give a further inflow of raw mud is admitted and the dry mass in the chambers is separated from the wet mud in the admission pipes. The external valve is then opened and the dry stuff is allowed to escape from the apparatus. Owing to the action of centrifugal force, the mass is violently thrown against the walls of the casing and thereby broken up into small particles. It is taken care of later by a conveying device located under the apparatus.

The violent action of throwing the mud against the screens tends to keep them fairly clean. In order, however, to insure more fully their cleanness, and in this way to prevent the stoppage of the flow of water, the screens are provided with a special mechanical cleaning device, viz., star shaped brushes which are given a reciprocal motion by a special drive. When the chambers are emptied, the outer valve is closed, the inner one opened and the process repeated. The valves are driven by oil under pressure which is admitted from below through a bore in the vertical shaft *f*. The admission of the oil under

pressure into the cylinder of the control valve is regulated by a rotating disc. The drum is enclosed in a strongly built casing and is driven by a belt. The parts of the casing which are subject to the action of centrifugally thrown masses are made of wrought iron. The drum shaft has three bearings, and in this way the weight of the drum is equalized through the oil under pressure admitted for operating the steering gear.

Around the centrifugal drum is located a concentric ring which takes up automatically the water escaping from the drum, and removes it shortly before the exit of the dry mass. After the dry matter has been taken care of, the ring returns automatically into its original position. This arrangement prevents the particles of water from staying on the periphery of the casing and mixing up again with the dry material thrown out by centrifugal force. In view of the great pressure exerted by the centrifugal force in the drum, it is impossible to prevent the appearance of water on the periphery of the casing even with the best packing of the valves, but the ring device described makes this water entirely harmless. The power consumption of this centrifugal separator is about 12 h.p. In order that the apparatus shall work without trouble, all large and hard pieces are removed previous to the entrance of the mud into the separator. This is easily done by passing it through a grating with slots 8 mm. (0.314 in.) wide.

The mass obtained from the apparatus can be used either for agricultural purposes or as filling material, and recently attempts were made to burn it in incinerators by gasifying it with some addition of coal. The tests of gasification and burning of the dried sewage sediment have been made at the Frankfort plant. The mud had been dried in the centrifugal apparatus to the extent of removing from 30 to 40 per cent of its water content. Then it was dried in drying drums by the use of flue gases down to 20 or 25 per cent of its water content, and in this state was added to the material fed to the incinerators in the ratio of one to ten. It was found that such an addition raised the output of electrical energy from 65 to 80 kva per 100 kg. (220 lb.) of mixture, which means an output of 150 kva per 100 kg. of mud. When the mud with 20 to 25 per cent water content is gasified, an average of 25 cm (per ? — not stated) of pure gas, with an average heat content of 4000 WE. at 448 B.t.u. per cu. ft. is obtained and, in addition, a valuable by-product secured, from 50 to 60 per cent of nitrogen contained in the sediment being converted into ammonia. The economy of the plant is still further increased through the utilization of the coke produced during gasification, which possesses a heating value of approximately 1200 WE. (2160 B.t.u. per lb.).

The article also contains data on the handling of the mud in municipal gas works of the cities of Brünn and Hanover. (*Trocknung von Klärschlamm und seine Verwendung*, Hubert Hermanns, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 37, no. 44, p. 485, October 30, 1914, *d.*)

## ENGINEERING SOCIETIES

### THE COLD STORAGE AND ICE ASSOCIATION

*Proceedings, vol. 11, no. 2, 1913-1914, London.*

Multiple Effect Compression as Applied to $CO_2$ Refrigerating Machines, H. Brier

Cooling of the Liquid $CO_2$ in Refrigerating Machines, F. A. Willcox and G. C. Hodsdon

Excessively Dry Air in Cold Stores, Wm. D. Sawers (abstracted)

Excessively Dry Air in Cold Stores, Wm. D. Sawers (20 pp., *p*).

The author discusses the action of excessively dry air in cold stores on the goods stored therein and the various ways of mitigating and regulating such action.

The favored system of air cooling in cold stores is the so-called wet brine method in which the circulating air is cooled by direct contact with refrigerating calcium chloride brine. This method, which has its advantages, produces, however, a dryness of air due to the powerful desiccating action of calcium chloride at low temperature. It appears that as the temperature of the solution goes down, the desiccating properties increase to an enormous extent and comparatively weak solutions of the salt which at normal temperatures would evaporate, take in moisture in a rapidly increasing degree as the temperature becomes lower.

The author made a number of careful tests of the relative moisture-absorbing properties of different strengths of calcium chloride solutions at different temperatures. The solutions were left exposed to the air in rooms maintained at temperatures of 60, 35 and 17 deg. fahr. and the loss and gain in weight due to evaporation or absorption of water noted at intervals. Ordinary fused calcium chloride was used for making the solution and three different strengths were made, approximately 20, 25 and 30 per cent. solutions, the other conditions of the test being kept as far as possible identical. At 60 deg. fahr., the brine loses moisture in a lessening degree as the strength of the solution used is stronger. With 30 per cent. solution, the action comes to a standstill and it neither loses nor gains water. At 35 deg. fahr., 20 per cent brine gives up water fairly rapidly and 25 per cent brine neither gains nor loses weight, while 30 per cent brine absorbs moisture from the air rapidly. At 16 deg. fahr., 20 per cent brine slowly absorbs, 25 per cent rapidly and 30 per cent takes in moisture with great avidity.

It is evident, therefore, that the drying action of calcium brine becomes very much intensified if too strong a brine is used, consequently the making up of brine in a cold store is a detail that requires more attention than it usually receives, the general tendency being to keep the brine unnecessarily strong, which is due principally to a dread of the solution freezing on the ammonia coils. On the contrary, the brine should be maintained so far as possible at a constant minimum density by putting in the calcium chloride frequently and in small measured quantities. With constantly moving brine at a temperature of, say, six to nine degrees fahr., the density can be quite safely kept well below 1.155 sp. gr. ($17\frac{1}{2}$ per cent) at 60 deg. fahr. The author found that actual practice of this procedure effected a decrease in consumption of calcium chloride; for a space of 90,000 cu. ft., over three tons less chloride were used on a year's run as compared with previous working, while the appearance of certain classes of goods coming out of storage is distinctly improved.

The best way to obviate this difficulty would be to find some other chemical which would serve as a suitable substitute for calcium chloride in the brine, but which would be free from the drying action. Magnesium chloride also possesses strong drying properties. Common salt absorbs

moisture to a very slight degree, but its solution does not remain liquid at low temperatures. The author tested a brine made of mixed calcium chloride and common salt, but found that curiously enough, the calcium chloride seemed to convey its properties to the common salt and the solution was as active a dryer as if it had been made with calcium chloride alone and had the same density. He suggests, therefore, the use of a cooler in which the air passes over dry metal surfaces, so constructed that the snow, as it forms, may be continuously and automatically scraped and brushed off, but he does not describe its mechanical design.

## ENGINEERING SOCIETY OF CHINA

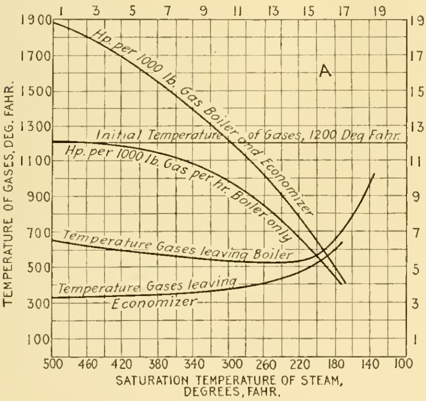
Report on Chinese Concrete.

The article gives a copy of a report made to the Engineering Society of China by a special committee which that Society appointed to investigate the question of reinforced concrete, such as preparation, strength, properties and use in engineering and building work, with special reference to local conditions in China. The article gives data on the materials used in the manufacture of concrete in China as well as the method of carrying out tests.

As the original publications of the Society of China are not available at the present time, the abstract is based on a reprint in *The Engineer* (London). The data of Table IV have been obtained. The results are by no means regular and the general superiority of the beams made with Pingchiao stone has been found in some cases. The difference between steel and iron is greatly in favor of the former. A consistent advantage was also found in favor of beams with hooked reinforcing bars as compared with beams with plain steel bars. In the case of iron bars, in some cases it was found that beams with hooked bars failed at a lower pressure than beams with straight bars. The first cracking invariably took place where the deflection was between $\frac{1}{16}$ and $\frac{3}{32}$ inches. At first, the cracks appeared distributed over the whole length of the beams at a distance of six to eight inches apart. With the increase of the load, the cracks nearest the center became larger, but when the maximum load was reached, with a deflection of $\frac{5}{16}$ to $\frac{3}{8}$ inches, a very distinct difference was visible between the beams reinforced with steel and those reinforced with wrought iron.

All beams reinforced with indented steel bars showed at the maximum load several wide cracks near the center tending to join each other at the top below the center where the load was applied. All other cracks further distant from the center had disappeared by then. Only three beams failed by the destruction of the bond between the steel and the concrete. All beams reinforced with wrought iron bars showed one large crack near the center, while all the other cracks had closed. In regard to slabs, those reinforced with steel failed more suddenly than those reinforced with iron.

Concrete was found to be less fire-resisting the greener and richer it was. None of the local materials can be considered as very fire-resisting in connection with concrete. Pingchiau stone, and especially gravel, have a tendency to destroy the concrete on account of their comparatively greater expansion. The report contains also data regarding the permeability of Chinese concrete and the effect of electrolysis. (*The Engineer* [London], vol. 118, no. 3072, November 13, 1914, p. 456.)



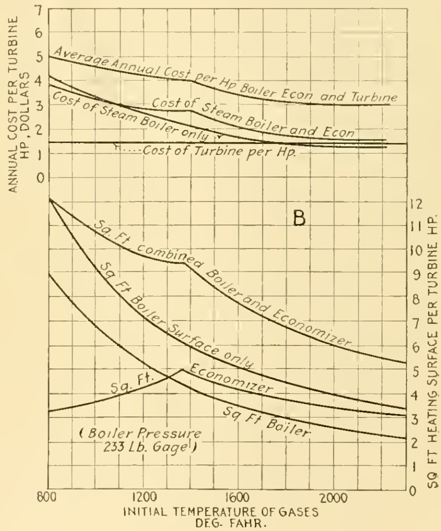




Fig. 6 Counter-Current in Economizers

## ENGINEERS' SOCIETY OF PENNSYLVANIA

*Journal, vol. 6, no. 8, August 1914, Harrisburg, Pa.*



The Counter-Current Principle as Applied to Directly-Fired and to Waste-Heat Boilers, George H. Gibson.

The author discusses the use of economizers with directly-fired and waste-heat boilers and comes to the following important conclusion: *First*, that with directly-fired boilers, contrary to the usual assumption that economizers begin to be profitable only when the price of coal reaches \$2.00 per ton and the load factor exceeds 50 per

cent, actually, economizers can be used profitably regardless of the fuel price and of the load factor. *Second,* in the case of waste-heat boilers, such boilers and turbines should be put in for as high steam pressures as are practical in view of other considerations, and the boiler should be supplemented by an economizer in order to obtain the greatest amount of power and at the lowest cost from a given amount of gases.

The author reaches these conclusions in the following manner: He begins by establishing the margin of diminishing returns as applied to waste-heat and directly-fired boilers. In the first case, the principle of diminishing returns expresses itself by the fact that there comes an economical limit to the recovery of waste heat beyond which it does not pay for the increased investment. In directly-fired boilers, after the gases have been cooled to a certain temperature, the heating surface required to cool them further does not produce steam as cheaply as it can be produced by the heating surface, including the cost of fuel, preceding that point. Thus, if the gases are to leave the boiler at 200 deg. above the steam temperature, there will be generated approximately $4\frac{1}{2}$ lb. of steam per hour per square foot of surface, and about 6.5 sq. ft. of surface will be required to produce a boiler horse-power of 30 lb. of steam per hour. With steam at 366 deg. fahr., the flue gases will be at 566 deg. and will still contain a large proportion of the total heat of the fuel. Assuming that 24 lb. of air have been used to burn one pound of combustibles, the loss will amount to approximately 25 per cent, and after allowing for radiation and other losses, the boiler efficiency will be less than 70 per cent.

To recover this heat by means of heating surface and steam temperature is not profitable, but it may be so done by giving up the heat to the boiler feed water in the economizer where, assuming that the economizer's heating surface will have the same coefficient of transmission and the same fixed charges as the boiler surface, we should theoretically be able to reduce the temperature of the flue gases in the above case to within 200 deg. of the initial water temperature, i.e., to 300 deg., with a saving of approximately 13 per cent of fuel (actually somewhat more, because the economizer surface costs less per square foot to install and requires less attention).

The author discusses in an interesting manner the rate of heat transmission in the case of the economizer, as well as the question of the coefficient of heat absorption by convection or contact. If cooled to within 200 deg. of the steam temperature, the gases from a directly fired boiler will not be sufficient generally to raise the boiler feed water to near boiling point, but as the water in the economizer is lower in temperature than the water in the boiler, the economizer surface is more active and hence more profitable than boiler surface up to the point when the water reaches the boiler temperature. It would pay, therefore, to reduce the amount of boiler surface per h.p. developed to less than $6\frac{1}{2}$ sq. ft. per h.p. required to cool the gases to within 200 deg. of boiler temperature. The author gives as an example a description of a 1000 h.p. boiler, superheater, economizer and mechanical draft unit, laid out according to proportions determined in his discussion, and shows how this installation confirms his views that if an economizer is not installed, the boiler must accomplish the same office in heating the water up to evaporation point, but will do it with a lower efficiency because the boiler also contains water at the steam temperature while the economizer utilizes the lower initial temperature of the water to increase the heat absorption.

In the waste heat boiler, if the steam temperature is near the initial gas temperature, the boiler must be large because of the small temperature difference available for transmission or inefficient because it must allow the gases to escape while still at high temperature. At the same time, the efficiency of the turbine or other engine will be good because of the high initial temperature and pressure. If the steam temperature be gradually reduced, the efficiency of the turbine will be poor, while the boiler required will be smaller and its efficiency high. Therefore, two solutions appear to be possible, viz., to have the boiler operate at a moderate pressure or to have a small boiler operate at a high pressure and another boiler and economizer at a lower pressure in connection with a mixed flow turbine receiving high pressure steam from a high pressure boiler and low pressure steam from a low pressure boiler.

It appears, however, that the commercially best and most practical solution is a high pressure boiler in combination with an economizer and a high pressure condensing turbine. For instance, at 366 deg. fahr., corresponding to 150 lb. gage pressure, about 12 lb. of steam are required per turbine h.p. (a turbine 65 per cent, Rankine efficiency, saturated steam exhausting to a 28 in. vacuum referred to a 30 in. barometer) at 212 deg. approximately 24 lb. of steam are required, but at atmospheric pressure the steam is worth only one-half as much per pound as steam 150 lb. gage, which determines to what extent it will pay to reduce the temperature of the gases by means of boiler surface. From Fig. 6, the curve marked "Temperature gases leaving boiler," it is seen that in any case it will not pay to reduce the temperature of the gases in the boiler below 500 deg. fahr., at least in competition with directly fired boilers burning \$1.50 coal. By installing an economizer to supply the heat required to raise the feed water from 100 deg. fahr. up to the evaporation temperature, the final temperature of the gases will be reduced as shown by the curve marked "Temperature of gases leaving the economizer." The higher the steam pressure carried, the lower the final gas temperature and hence the greater the capacity as well as the economy of the unit.

The most striking result, however, of using the economizer is the greater increase in horse-power obtainable from each 1000 lb. of gases as shown by the curve marked "Horse-power per 1000 lb. of gas from boiler and economizer," the increase at ordinary steam pressures being about one-third. To determine, also, the variation in the cost of power produced by using the economizer, it is necessary to fix the annual costs of the two kinds of apparatus (Fig. B). For the boiler \$2.00 per square foot has been assumed as the cost installed, including settings, flues and fittings, with an annual charge including repairs, depreciation and attendance taken at 17 per cent. For the economizer, the cost per square foot installed has been put at \$1.50 and the annual charges at 15 per cent. A high pressure turbine has been assumed to cost \$10.00 per h.p., installed complete with condensers and auxiliaries and the turbine receiving steam at atmospheric pressure, \$20.00 per h.p. From the curves of total cost, including the steam cost, it will be seen that if the plant is operated with saturated steam at the initial temperature of 400 deg. fahr., the annual cost per h.p. is \$4.10. The same with the turbine receiving steam from a directly

fired boiler using coal at $1.50 per ton would cost a little over $10.00 per year. From Fig. B it might appear, however, that when using the economizer, power costs more than when using the boiler only, but there the boiler is terminated at the point where it ceases to be able to compete with the directly fired boiler with $1.50 coal. From there on, the gases are allowed to pass through an economizer in which they give a better return, until they can reach the same limit.

In a plant where the waste gases would produce a surplus of power, it might not be advisable or necessary to add the economizer, but as soon as the need of burning fuel under boilers to produce steam for power appears, it will pay to add the economizer both because of the greater amount of power thus obtainable from a given amount of waste gases and because the power so obtained is secured more cheaply than it would be secured from a directly fired boiler.

(17 pp., 13 figs. *pe.*)

### ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

*Proceedings, vol. 30, no. 6, July 1914, Pittsburg.*

Test of Large Reversing Engine and Rolling Mill, Karl Nibecker (107 pp, 56 figs. *edA*).

The article describes a twin tandem compound reversing

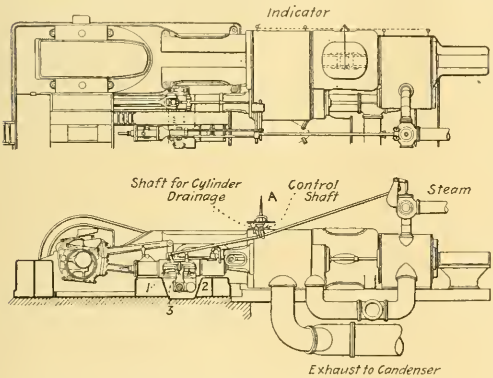



Fig. 7 Valve Gear of Reversing Rolling Mill Engine

engine driving a 44 in. reversing bloom mill when rolling 20 x 22 in. ingots, as well as the methods used in testing that engine and assumptions made in determining the power and steam consumption for this mill. Further, it considers the steam consumption per unit of metal deformed and the power losses involved in this operation.

The engine is operated condensing, using steam at 140 lb. gage pressure at the throttle valve and exhausting into a 28 in. vacuum. It is direct connected to the mill, but separated from it by means of a brick wall. Fig. 7 represents a diagrammatic arrangement of one side of the engine and valve gear, showing the method of control. It has been previously used in Europe, but is rather new in this country. The mechanism is operated by a single lever shown at *A*. This lever, located in a pulpit, operates the relay valve which controls the steam to the reversing cylinder operating both the reversing links and the throttle. The reversing piston is cushioned by means of a suitable oil cylinder connected to the reversing gear crosshead.

The three positions of the main reversing lever crosshead are shown by points 1, 2 and 3, the pressure of the steam through the throttle valve and the point of cut off being both determined by the motion of this cross-head, and it is essential therefore that the engine when operating under light loads, should work with the combination of throttle and cut-off control. The throttle valve is so arranged that its opening does not occur with the beginning of the movement of the reversing lever from its center position. A certain amount of lap is provided so that the valve gear is moved an appreciable amount from its neutral position before the steam valve is opened. When the throttle valve opens, the steam is admitted from auxiliary ports in the main piston valve. By this combination of lap on the throttle valve and auxiliary ports in the main valve of the engine, it is possible to start the engine at any position of the cranks. The auxiliary ports are in operation during the regular running of the engine but are too small to affect the economy of the engine or the shape of the indicator cards.

Continuous indicators were applied to each end of the four cylinders, equipped with electro-magnets for starting and stopping the paper and also for applying the pencil to the drums. The other four indicators were manually started and stopped at a given signal operated by the same key which actuated the starting magnets on the electrically operated indicators and were supplied with electro-magnets for locating the various events. The point of opening and closing of the steam throttle valve was recorded by means of one magnet. The position of the cross-head of the reversing cylinder was determined by a magnet on one of the indicators which indicated when the piston of the reversing cylinder was in its dead center position and when it was off the dead center position. The dead center position of this piston represented the point where the steam throttle valve was closed and the links were in their neutral position. On one indicator, a magnet was provided for recording one-half second intervals, thus giving a record of time. A figure in the original article is given to show the electrical connections but unfortunately it is too blurred to permit reproduction here. Storage batteries were used for furnishing the current for operating the instruments, and temperatures were read by means of a Wanner optical pyrometer. A three point recording thermometer was installed on the condenser and also a vacuum gage carefully calibrated by means of a mercury column.

The author describes in detail the methods used in working up the indicator cards which are those described by Siebert and Fitzgerald in the *Proceedings of the Engineers' Society of Western Pennsylvania,* volume 29, No. 8. It was found that 34.5 per cent of the total available work is consumed in accelerating and retarding the rotating and reciprocating parts, 9.8 per cent in friction and only 55.7 per cent is actually consumed in deformation of steel. The amount consumed by the engine in accelerating and retarding the parts is in this case inordinately large as tests on other engines have shown that this value can be as high as 15 per cent only and even lower. The engine in question, however, runs without the slightest vibration and has shown no wear on boxes, pins or bearings. While smooth running is a desirable feature, it does not always pay to spend too much in steam consumption to obtain it. On the other hand, the amount of power consumed in friction, 9.8 per cent, is exceptionally low and has been obtained by large short bear-

ings properly lubricated and by perfect alignment. The couplings used are of a special design and machined to eliminate all lost motion and reduce friction. Cut pinions are also used. The average value of the steam consumed per i.h.p. hour is only about 21 lb., which is exceptionally good.

This engine disproves the statement sometimes made that it is impossible to produce a high vacuum in the cylinders of a reversing engine since a vacuum of 25 in. in the low pressure cylinder has been here obtained with 28 in. in the body of the condenser. The author describes the low steam consumption of the engine to single lever control, and the consequent importance of using a large amount of steam for "plugging" the engine and throttling the steam for controlling the engine, as well as to well set valves giving high compression. At the same time, the engine has been found to reverse quickly: it requires approximately three-fifths of a second to move the lever through its entire travel and one and one-half seconds are required from the beginning of the movement of the reversing lever until the links are fully reversed. From one-half to one second is the time required for the links to reach their new extreme position after the lever has been thrown to its new extreme position.

The author calls attention to the excess of steam consumed per ton due to difficulty with manipulation of the piece and also to the piece not entering the rolls properly. With very little trouble, the steam consumption per ton can be increased 30 per cent, and it has been found also that one operator may use from 10 to 15 per cent more steam than another, although both may be considered expert engineers with a large amount of practice upon this mill. The author reproduces a table showing the increase which may be met with when rolling various sizes under different conditions of temperature and handling of the piece. In general, it appears that with a moderate amount of ordinary difficulty in manipulation and operation, the mill should consume less than 500 lb. of steam per ton of steel rolled constantly. A summary of the results as calculated by H. C. Siebert is given in Table 10:

TABLE 10 SUMMARY OF RESULTS

| | | |
|---|---|---|
| Set Number | 7 | 15 |
| Weight of Ingot—tons | 2.74 | 2.46 |
| Length of Ingot—ft. and in. | 4 ft. $9\frac{5}{16}$ in. | 4 ft. $2\frac{13}{16}$ in. |
| Average Area of Ingot—sq. in | 379 | 399 |
| Section of Bloom—in. | $4\frac{7}{8}$ x $6\frac{3}{4}$ | 7 x $5\frac{1}{8}$ |
| Area of Bloom—sq. in | 32.9 | 35.9 |
| Length of Bloom—ft. and in. | 55 ft. 0 in. | 47 ft. 0 in. |
| Elongations | 11.52 | 11.10 |
| Indicated Work—h. p. sec | 211,106 | 206,113 |
| Friction Work—h. p. sec. | 37,465 | 33,690 |
| Acceleration Loss—h. p. sec | 61,901 | 77,014 |
| Available for Rolling—h. p. sec. | 111,740 | 95,409 |
| Friction Work—per cent. | 17.8 | 16.4 |
| Acceleration Loss—per cent. | 29.3 | 37.3 |
| Available for Rolling—per cent. | 52.9 | 46.3 |
| Total Steam—lb | 1,302 | 1,272 |
| Steam per Ton for 11 Elongations—lb. | 475 | 515 |
| Steam per i. h. p. Hour (Dry from Ind. Cards)—lb | 17.1 | 17.1 |
| Steam per i. h. p. (Plus 30 per cent for losses) lb | 22.2 | 22.2 |
| Temperature—deg. fahr. | 2,245 | 2,200 |

In the discussion which followed, Charles Fitzgerald, Jr., took exception in regard to the test methods to the marking of one-half seconds points on the indicator paper for the purpose of plotting speed curves since the instantaneous linear speed of the paper is proportional neither to time nor to the speed of the engine. The curve plotted in this manner shows only approximately the general shape but is not valuable as a means of applying a kinetic energy factor to the solution of the problem of actual force applied at the rolls. The location of the passes by this method is also open to error unless checked by the indications of a correct speed curve which shows plainly the period of the bloom in the rolls. The speaker thinks that 18 lb. per i.h.p. looks too good to be true.

## FRANKLIN INSTITUTE

*Journal, vol. 178, no. 6, December 1914, Philadelphia, Pa.*

WING DATA AND ANALYSIS FOR A STAGGERED BIPLANE, A. F. Zahm (16 pp., 9 figs. *p.*)

The article presents data for a staggered biplane with the spars continuous from body to wing and the angle of incidence varying with the speed, thus causing the line of resultant lift to travel.

The article is too long to be fully abstracted here and only certain parts will be given. Fig. 8 shows that as the wing of incidence varies throughout its assumed range of 0.5 to 12 deg., the center of pressure moves fore or aft through about one-fourth the chord; thence, if the spars be placed

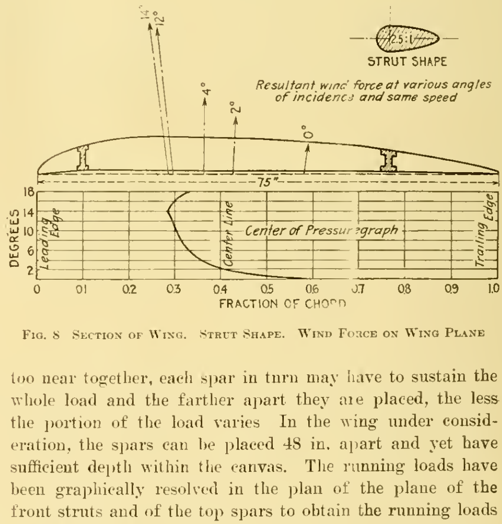



FIG. 8 SECTION OF WING. STRUT SHAPE. WIND FORCE ON WING PLANE

too near together, each spar in turn may have to sustain the whole load and the farther apart they are placed, the less the portion of the load varies In the wing under consideration, the spars can be placed 48 in. apart and yet have sufficient depth within the canvas. The running loads have been graphically resolved in the plan of the plane of the front struts and of the top spars to obtain the running loads in these planes and hence the tensions and compressions borne by the truss members in the planes. Likewise, they have been resolved in the plan of the spar web in order to define the bending moment of the spar due to the net running load on it.

For the spacing of the struts along the spars the following method was used. The distances between the struts along the wing were so chosen as to make the bending moment in any spar the same as that of its strut joints. Thus the overhanging wing end is a uniformly rotating cantilever beam and has a bending moment next the strut of $\frac{Wl}{12}$ if $W$ be the known running load on the spar and $l$ the length of the overhang. The next span is a uniformly loaded beam

with fixed ends and next to each strut, has the bending moment $\frac{Wl_2^2}{12}$, where $l_2$ is its length. The next span is a uniformly loaded beam fixed near to the strut and pinned at the engine section and next to the strut has the bending moment $\frac{Wl_3^2}{8}$, $l_3$ being its length. Since these three moments are to be equal

$$\frac{Wl_1^2}{2} = \frac{Wl_2^2}{12} = \frac{Wl_3^2}{8}$$

and since the sum of the span length equals the given wing length

$$l_1 + l_2 + l_3 = l$$

the equations can be solved for $l_1$, $l_2$ and $l_3$.

The article discusses in detail the graphical determination of the applied forces and reactions in the plane of struts and in the upper and lower planes as well as the assembled dimensions and computed values and proceeds then to the total analysis of stresses and loads.

### NEW ENGLAND RAILWAY CLUB

*November 10, 1914, Boston.*

Typical Rail Failures, F. A. Weymouth (46 pp., 46 figs. *dp*). The paper describes various causes of rail failures, gives a classification of defects, and discusses the so-called frictionless rail.

A logical classification of rail failures seems to be one that places them under headings descriptive of the manner in which the failure develops or occurs in service. The author considers rail failure under four main headings: first, crushing of the head; second, flowage of the top metal of the head; third, broken rails, and fourth, rails worn out from abrasion. Under the heading of *crushed head failures* are placed all rails that indicate a flattening of the head or breaking down of the head structure, *i. e.,* the under side of the rail head shows distortion. Many of the crushed-head rails are called also "split-head" when they show a splitting of the head; but this term is merely an amplification of the term crushed-head. Some rails are termed "piped," which suggested that this type of failure comes from the presence in the rail of unwelded surfaces of the original cavity of the ingot. Naturally, however, only very few failures are traceable to this cause and it seems best to use the term "crushed-head" in all such cases.

Crushed-head rails in track are readily detected in three ways: first, a widening out of the head is very apparent in tracking; second, a dark streak appears in the center of the top of the head of the crushed portion, indicating that that portion of the metal is depressed and is not receiving the usual brightening from the wheels; and third, the distortion or breaking down of the head structure can be detected by a sufficient template or the appearance of a ferro streak in the head. The crushed head occurs partly because of the battering of the top surface of the metal due to low joints and also because of uneven tamping of the ties. It may occur in unsegregated rails as well. This has been shown by a special machine designed at the Maryland Steel Company for the purpose of reproducing the condition of the wheel loading that the rail gets in service.

The term "flow of metal" failure is used to describe rails that show a rolling-out or *flowage* of the top metal of the head toward the sides without a breaking down of the head structure. It may occur in many different forms and be due to various causes, such as improperly maintained or poorly designed joints, a vertical movement of the rails and especially the effect of different types of supports. One of the most annoying types of flow metal is that which has been given the name "flow in spots," which causes what is sometimes called a "roaring" rail. These spots occur on the gage corner of the head. No satisfactory explanation of this type has been evolved, but intense localized wheel pressure which stretches the metal beyond its elastic limit is one of the causes mentioned. The effect of slipping drivers and all slipping wheels is also very marked in the development of rails that fail from flow of metal. While flowing metal itself is not dangerous, it may form a starting point for the development of splits, crushed heads and breakages.

The author proceeds to discuss failures from breakages such as flange breaks, breaks across the rail section, and breaks in the web. He discusses the claim that flange breaks are the result of lack of transverse ductility in the rail accompanied by the presence of seams and agrees with the view that a large number of flange breaks are due to the presence of seams which are elongations of small cracks formed in the ordinary process in rolling the ingot. As regards the action of slipping drivers, an investigation was made by placing in one of the tracks of the Maryland Steel Company a rail which was then slipped on by a light locomotive. The rail was then removed from the track and bent under the tensile machine. At the part where the rail was not slipped on, it stood a load of 200,000 lb. without fracture, while at the point where the drivers had slipped on the rail, it broke at 160,000 lb. pressure. Scleroscopic hardness tests made on that part of the section showed 80 hardness against 37 for the average for the rest of the metal in the head.

The name of transverse fissure is given to a fractured rail section that shows smooth track or silvery spots in the head, while the rest of the metal is granular. It is found on the fractured surface usually without any connection with the outside skin of the rail, indicating that it is an internal fissure that radiates from a nucleus. No satisfactory explanation of the cause has as yet been evolved.

As regards rail abrasion on straight track, normally only simple flowage is found due to the wheel pressure and the wearing away of the top fillet of the rail on the gage side to fit the nuts of the wheel flange or on curves; a number of different types of rail wear is found, each imposing a different set of strains upon the rail. The author proceeds to discuss the wear on the high rails, the influence of worn wheels on the shape of the rail (formation of false flange on the rim) and finally the use of the so-called frictionless rail.

### NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

*Advance copy of paper read at meeting on November 27, 1914, Newcastle-upon-Tyne.*

The Remarkable Failure of a Consignment of Steel Ship Plates, W. J. B. Wilson (11 pp., 11 figs. *deA*). The paper describes an unusual failure of steel plates used in the construction of an ice breaker and the tests performed on these plates. It shows that such usual tests as chemical analysis, tension, bending, punching and forging tests, as prescribed by Lloyd's, are not always sufficient to determine the properties of the material, and steel which fully satis-

fies such tests may prove to be entirely unfit for service under these difficult conditions (winter service, etc.).

In 1907, the author's firm received an order for an ice-breaking cargo and passenger steamer to be built to Lloyd's highest class under special survey. The material for the shell had been tested and passed by Lloyds and characterized by the surveyor as excellent. In punching the garboard strake plates, several of them cracked, the failure having been put down to the severe cold prevailing (-13 to 18.4 degrees fahr.). Later on a number of garboard plates cracked between the rivets, and some of them were so brittle that a single blow with an ordinary hand hammer knocked pieces out of the flange portion. The job of riveting the keel was at once stopped until a thorough hammer test of the flange portion of all the remaining garboard plates had been made. This proved perfectly satisfactory and the riveting was resumed. For some time practically no cracks occurred, then the cold again became very severe and several days later, one of the garboard plates which had been riveted in the ship was found to be badly cracked, the crack being clearly a case of spontaneous rupture. When this plate was cut out, the material in the way of the keel rivets cracked in the same way as the one described above and a new hammer test was made therefore with the startling result that every plate in the garboard plates cracked and in some cases, pieces fell out. A new survey was then made by Lloyds which proved satisfactory to the surveyor. The bend tests were excellent so long as the test pieces were not taken near any rivet holes. Chemical analysis for phosphorus was good, but still one blow of a heavy hammer was sufficient to knock large pieces out of the flange portion of the plate.

The article gives extracts from an official report of tests made, which indicated that the plates satisfied all usual requirements; after these tests have been made, the surveyors maintained that as the steel passed the test laid down in the rules, they were not justified in blaming the material unless a test could be devised which would, in their presence, prove the steel to be at fault. The author then devised a test carried out in the following manner: a butt strap which had not been worked into the vessel and a plate of material made in a Swedish steel works were placed in a mixture of ice and salt and the temperature of the plates reduced to -4 deg. fahr. The plates were then quickly punched on one side for double riveting and riveted together, care being taken that the edges of the plate opposite the holes were kept cold with ice. After the plates were allowed to cool down, the rivets were driven out, during which operation the plate taken from the ship's material cracked badly and pieces dropped out. The plate from the Swedish steel works was also inspected but did not show any signs of cracks. These butt strap tests were sufficient to show that the material was really entirely spoiled by riveting, and that the Swedish material, although worked in the same way, gave no trouble at all.

The case of the plates was submitted to Prof. J. O. Arnold of the University of Sheffield, who made the following report. The chemical analysis was:

Chemical Analysis

| | Per cent | | Per cent |
|---|---|---|---|
| CC. | 0.05 | S. | 0.08 |
| Gr. | trace | P. | 0.06 |
| Si. | 0.08 | As. | trace |
| Mn. | 0.86 | | |

The material is a dead-mild steel which, from a chemical point of view, is not of very good quality. A micrographic examination of the material showed the structure reproduced in the accompanying micrograph (Plate 1.). The very small carbon contents are centered into dark etching areas, best described as the fourth phase of pearlite, namely, when it is passing into ferite and massive cementite. When such high sulphur as 0.08 per cent is present, dove grey areas of sulphide of manganese are scattered through the steel in very appreciable numbers. The crystals have sharp angular boundaries; indeed, the material appears to have been overheated in the manufacture, and gravely injured by the operation.

A number of alternating stress tests were made, giving extremely unsatisfactory results. The conditions of testing were the standard method adopted here, viz., the bars were 3/8 in. diameter, and the distance from the zero of stress to the plane of maximum stress 3 in.; the deflection each way on the zero plane was 3/8 in., and the rate of alternation 650 per min.

Good mild steel should endure a minimum of 300 alternations of stress. The faulty steel, however, in 8 tests averaged only about one-third of this, or 100 alternations. This is the worst steel of its class I have ever examined under alternating stress.

I have not had the tensile tests made, as in such cases these would be of very little use, usually giving very fair results. As regards the bends, I send also three of the bars used in the alternating stress tests. As you will see, they have bent double without any sign of a flaw. This also is quite usual.

I am a little puzzled as to the origin of this steel, since the high silicon, 0.08 per cent, suggests an acid steel. It may, however, be a basic steel, overtreated with ore, to which manganese and silicon have been added in the ladle. If the carbon were, say, 0.2 per cent instead of 0.05 per cent, I should with some confidence class it as Bessemer steel; as it is, I find it difficult to suggest its method of manufacture with any degree of certainty.

The overheating to which I referred would take place in manufacturing the plates from the slab ingots. When such ingots are heated to too high an initial temperature and rolled, they leave the rolls at too high a temperature, cool too slowly and crystallize, and if such plates are stacked in heaps to cool, it is obvious that the cooling is still slower, and the crystallization more perfect, and hence more dangerous. . . .

This shows that the ordinary methods of testing, such as adopted by Lloyd's, are not sufficient to detect certain kinds of weaknesses in the materials; this is of extreme importance in ship construction on account of the tremendous stresses to which boats built for winter traffic are subjected. Only the very finest material can be used in such cases and had, for example, this vessel been launched without notice having been taken of the first crack, it would have been classed as 100 A-1, but the very first attempt at ice breaking would doubtless have ended disastrously.

### OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

*Journal, vol. 7, no. 1, November 1914, Columbus, O.*

Centrifugal Pumps for Boiler Feed Service, Edward S. Adams

Some Chemical Aspects of Boiler Feed Waters, Charles W. Foulk
Cooling Towers and Cooling Ponds, Walter G. Stephan (abstracted)
Coal Crushing Equipment for Power Plants, George D. Francisco
Technical Museums, Frank E. Sanborn
Safety First as Applied to Traveling Cranes, Henry F. W. Arnold

Cooling Towers and Cooling Ponds, Walter G. Stephan (4 pp., *gd*). The article discusses the design and use of cooling towers and cooling ponds in connection with the installation of condensing apparatus, the theory of their design and some tests made on cooling towers.

In the best commercial practice with the forced draft towers, it is possible to cool water to a temperature of about 15 deg. above the temperature of the dew point. With the natural draft tower, it is practical to cool to 20 deg. above the temperature of the dew point. The drop in temperature can be made considerable, but it seems to be more difficult to cool from 95 deg. to 85 deg., for example, than it is to cool from 125 deg. to 85 deg. with the same atmospheric conditions. The author gives formulas for the determination of the heat given up through convection and evaporation by water pumped over a cooling tower. With other conditions remaining the same, the temperature ratio of air-out to water-in represents the real efficiency of a cooling tower. In a well designed cooling tower, the humidity of the air leaving the tower is always 100 per cent. The terminal temperature difference will vary anywhere from 5 to 15 or 20 deg. Interesting tests on cooling towers were made by the Wheeler Condenser and Engineering Company of Carteret, N. J., the results of which are printed in Table 2:

TABLE 2 TESTS ON A FORCED DRAFT COOLING TOWER

Averages of Three Hours Readings

| Water | | | | Air | | | | |
|---|---|---|---|---|---|---|---|---|
| Gal. per min. | Temperature Deg. Fahr. | | B. t. u. per min. | Temperature Deg. Fahr. | | Humidity Per Cent | | Quantity measured by anemometer Cu. ft. per min. |
| | In | Out | | In | Out | In | Out | |
| 651 | 105 | 84.7 | 110,000 | 71 | 90 | 40 | 100 | 53,900 |
| 638 | 107.8 | 87.5 | 108,000 | 72 | 93 | 60 | 100 | 50,100 |
| 638 | 112 | 88.5 | 124,500 | 64 | 96 | 60 | 100 | 51,400 |
| 643 | 108.5 | 87 | 115,000 | 69 | 92 | 48 | 100 | 52,200 |
| 640 | 109.9 | 90.5 | 103,400 | 83 | 95 | 48 | 100 | 50,600 |
| *632 | 116 | 98 | 94,800 | 43 | 101 | 75 | 100 | 23,500 |
| *630 | 135 | 115.8 | 102,000 | 60 | 118 | 73 | 100 | 15,575 |

* Natural draft, fan not running.

The quantities of air were obtained by anemometers which were moved back and forth across the top of the tower at regular intervals and the results obtained were corrected so as to give the correct amounts entering the tower. The water was measured both by a Venturi meter and a calibrated Pitot tube.

In later experiments made with a view to increasing the efficiency of the towers, the quantity of air was not measured but the following results were secured in which it is to be noted that the temperature of the out-going air is only 3 deg. below the temperature of the in-flowing water. This test was made on a large installation consisting of a special Wheeler-Balcke forced draft tower.

| | | |
|---|---|---|
| Water | Gal. per min. | 3200 |
| | Temp. in | 109 deg. |
| | Temp. out | 97 deg. |
| Air | Temp. in | 91 deg. humidity 59 per cent. |
| | Temp. out | 106 deg. humidity 100 per cent. |

It is quite possible to cool water below the temperature of the air, this depending, however, on the air humidity. It is of course important to secure the lowest practical temperature of cooling water. A difference of 10 deg. lower initial temperature of the circulating water in a surface condenser may mean a difference between a vacuum of 27 in. and a vacuum 27¾ in., and ¾ inches of increased volume may mean quite a large saving in coal cost per year.

## WESTERN SOCIETY OF ENGINEERS

*Journal, vol. 19, no. 8, October 1914, Chicago.*

The Future Sanitary Problem of Chicago. A Symposium, E. H. Lee, J. W. Alvord, George A. Soper, John D. Watson, Arthur J. Martin

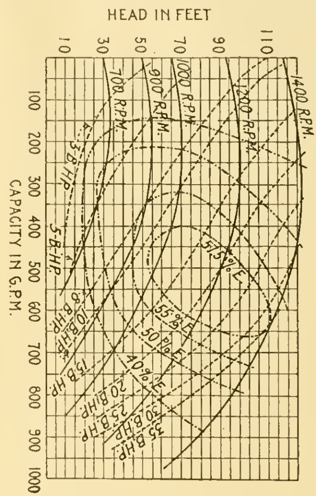



Fig. 9 Characteristic Curves of Centrifugal Pumps

Characteristic Curves of Centrifugal Pumps, F. William Greve, Jr. (abstracted)
Sewage Disposal Plant at Aberdeen, South Dakota, W. G. Potter

Characteristic Curves of Centrifugal Pumps, F. William Greve, Jr. (12 pp., 5 figs. *et*). The article treats of characteristic curves of centrifugal pumps as a means of illustrating a method of diagramming experimental data pertaining to centrifugal pumps. The curves deal with the head, speed, capacity, horsepower, input and output, and efficiency of a four-inch centrifugal pump.

The article contains five diagrams, of which only diagram Fig. 9 is reproduced here. Three series of curves have been plotted on it, the set showing the relation between head in feet and capacity in gallons per minute with the speed remaining constant for any one curve, and shows how the head decreases with increase of capacity except for very small discharges. At the same time, the maximum head does not

occur at the minimum discharge but at a point equal to about one-third of the maximum. If continued, these curves would have dropped on a line approaching the vertical. Another diagram illustrates the changes in efficiency for various values of capacity when computed for a constant speed. Up to a certain limit (variable) the maximum efficiency and capacity are found to increase with an increase of speed. For small discharges the efficiency is practically the same at any speed, and in general, the shape of the curves resembles a semi-ellipse. The horsepower input is found to increase with the discharge after a given speed until the point of maximum capacity has been reached when the curve becomes horizontal. The curves determining the range in head for various speeds with the discharge remaining constant approach closely those of straight lines and for large quantities may be assumed as such. In the diagram (a series of curves drawn from the upper left to the lower right end of the sheet show the horsepower required to discharge any quantity of water against any head and at any speed within the limits of the pump. The author fully explains the method of determining these curves and especially the use of interpolation.

The efficiency curves are similar to an ellipse, the major and minor axes of each curve intersecting in a common point of origin, which is also the point of maximum efficiency. The fact that these Iso-Efficiency curves are concentric is important, as when the efficiency is required for which no curves have been drawn, a new curve may be sketched in with reasonable accuracy. The advantages of representing the determinations of a pump by such curves lie in the fact that in any series of curves on the diagram, the curves are parallel or nearly so. This diagram may be considered to represent a map upon which the characteristics of the pump are indicated so that questions referring to the relations of speed, discharge, head pumped against, horsepower input and output may be answered by reference to it. The author points out that when more than one diagram is used in representing test results, there is danger of error when the eye is deflected from one diagram to another and that a single diagram is more convenient.

In the discussion which followed, Mr. H. S. Baker told of the wide adoption of centrifugal pumps in city water works. The city of Chicago has a number of such pumps, as well as the cities of Toronto, New York and Buffalo. The city of Cleveland has just purchased a twenty-five million gallon unit to work against a head of over 200 ft., while the city of Philadelphia has received bids for a number of centrifugal pumps to be driven by steam turbine.

Mr. Bowen told of a curious experience of a friend of his who has charge of seven large pumping stations with heads ranging from 85 to 340 ft. "He has no centrifugal pumps, but he made a statement to me which was indeed very interesting. From one of these stations, which is used for irrigation purposes, the water is taken off at several different levels, making several different heads; and the statement he made was, that when the water was taken off the discharge line at maximum head, the fuel consumption was quite a little greater than when a portion was taken off at high level and a portion at low level, and when the pumps were running at the same speed and therefore delivering the same volume of water. The head of pump, as indicated by gauges, was exactly the same in each case, which would indicate that the pumps were doing exactly the same work under the two conditions, but the fuel consumption was different. If this is true, which is hard to conceive, then perhaps the testing of pumps in manufacturers' plants, where heads are created by a valve in the discharge line, may give results which will differ when the same head is obtained in actual operating conditions."

*Vol. 19, no. 9, November 1914*



PERMEABILITY TESTS ON GRAVEL CONCRETE. Morton O. Withey (46 pp., 20 figs. *eA*). The paper is a preliminary report on tests now conducted at the University of Wisconsin to determine the permeability of concrete to water, started at the suggestion of the Inspection Bureau of the Universal Portland Cement Company. The tests cover the effects on permeability of age, thickness, consistency of concrete, time of mixing, gradation of the aggregate, wet and dry sand, fineness of cement, and curing conditions. Only tests on gravel and sand aggregates are here considered, although work is being done on mixes containing sand and broken stone. The tests are somewhat unique because of the use of machine-mixed concrete and the employment of large specimens having a prescribed volume of concrete subjected to water pressure and the measurement of the water entering the specimens during a large number of hours.

The results of the tests are presented in the form of tables and sometimes curves. None of the test pieces showed visible signs of leakage, but from various evidence, it seems certain that the water went through the specimens and it is indicated that the rate of flow for the 20 to 50 hr. period on a specimen which has previously been subjected to water pressure is about the same as the rate for a similar specimen tested for the first time and it appears that the permeability of so-called impervious concrete is unaffected by age after being properly cured for one month. It appears that the rate of flow for specimens having no visible leakage is independent of the thickness, although it is barely possible that the pores in the top surfaces of the thin specimens were sufficiently compressed by the bending of the core under pressure to reduce the rate of flow. The effect of grading the sand and gravel into different sizes and recombining these sizes in such a way that the maximum density may be obtained, has been very carefully studied. If mixes containing practically the same proportion of cement by weight are compared, it will be found that the batches which were most impervious were of 1:5, 1:7 and 1:9, and most of the mixes have a higher proportion of fine particles than demanded by Fuller's theoretical curve.

In general, it was observed that the flows decreased as the density increased, and one of the figures indicates that either the ratio of the volume of the cement particles to the volume of air voids in a unit volume of concrete or the ratio of the volume of cement particles to the volume of air plus water voids furnishes an index of imperviousness, the former seeming a better index than the latter. It appears further that permeability is influenced much more than strength by a change either in the proportion of cement or in density.

From these tests the following conclusions applicable to concrete made of like materials may be drawn:

1. None of the concretes tested were absolutely watertight if we consider continuous flow into the specimen as proof of permeability, but the majority of the mixes were so impervious that no visible evidence of flow appeared. For most purposes such mixes can be considered watertight.
2. The visibility of dampness on the bottom of the specimens increased with the humidity of the air and the non-homogeneity of the concrete. The minimum rate of flow for which leakage was indicated was 0.00011 gal. per sq. ft. per hr.
3. In tests of nearly all of the properly made mixes of 1:7 proportions, or richer, the rate of flow for a fifty-hour period was less than 0.0001 gal. per sq. ft. per hr. under a pressure of 40 lb. per sq. in.
4. Through increasing the fineness of the cement, a reduction in the rate of flow and a considerable increase in the strength of a 1:9 mix were secured.
5. By grading the sand and gravel in accordance with Fuller's curve, it was possible to obtain practically watertight concrete of 1:9 proportions under pressure less than 40 lb. per sq. in. To secure such results, however, requires great care and careful supervision in mixing, in determining the proper consistency, in placing, and *in curing* the concrete.
6. In the proportioning of such materials as these, volumetric analysis coupled with a determination of the density and air voids yields very valuable information concerning the best proportions of sand and gravel for a given proportion of cement. If proportions must be selected arbitrarily a 1:1½:3 mix, by volume, is very impervious. It should be remembered, however, that the volume changes in rich mixes due to alternate wetting and drying are much greater than for lean mixtures. Consequently, due attention must be given to the provision of expansion joints and reinforcement in structures made of them.
7. The use of the proper amount of water necessary to produce a medium or mushy consistency is one of the most important conditions in securing impervious concrete, especially when lean mixtures are used. Dry mixtures cannot be sufficiently compacted in the molds and are more difficult to cure properly than the mushy mixtures. Although the use of a wet consistency does not materially affect the imperviousness of very rich mixes, such as 1:1½:3, it greatly increases the flow through a lean mix.
8. For lean mixes made from damp sand it seems advisable to mix longer than is now the common practice. These tests would indicate that for a mixer running at 30 r.p.m., a period of one and one-half to two minutes is required to secure thorough mixing of a 1:9 concrete, for a rich 1:1½:3 mix a one-minute period appears to be sufficient. The method of mixing in which water is first admitted to the mixer is to be condemned. A preliminary period of drying mixing lasting from 15 to 30 seconds seems desirable.
9. No stage or process in the making of impervious concrete is of more importance than curing. The results of these tests clearly demonstrate that premature drying destroys the imperviousness of 1:9 mixes, seriously impairs that of the 1:2:4 mixes and somewhat diminishes that of the 1:1½:3 mixes. For thin sections, not over 6 or 8 in. thick, the curing conditions should be such that a lean concrete will be kept damp for a period of one month and a rich concrete for at least two weeks. Even after a month of proper curing, complete desiccation of a lean mix composed of these materials produces an increase in permeability, but the effect on a rich mix is not marked.
10. In these tests, the imperviousness of the concrete increased rapidly with the age of the specimens for the first month; thereafter the change was not marked.
11. From the tests thus far made it seems probable that the permeability of lean concrete in a direction normal to the pouring is greater than in the direction of pouring.

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The various articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

# MEETINGS

## ATLANTA, SEPTEMBER 19

The second annual barbecue of the Affiliated Technical Societies of the City of Atlanta was held on the grounds of the City of Atlanta Pumping Station on September 19, 1914, with about 80 men present.

These meetings are held for the purpose of stimulating interest in the various local organizations, promoting the welfare of the national societies and advancing the interests of Atlanta. The following organizations were represented: the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Chemical Society, the Engineering Association of the South, the American Institute of Architects, and our own Society.

The meeting was called to order by A. M. Schoen, chairman of the executive committee of the affiliation, who briefly outlined the object of the meeting, its plans and expectations. He was followed by Paul H. Norcross, member of the Engineering Association of the South, who spoke upon the benefits of such gatherings and the fraternal spirit of the affiliation. Prof. T. P. Branch, a member of the American Society of Civil Engineers and of the Engineering Association of the South, spoke of the need of technical men in all technical positions. An interesting talk upon Physics and Chemistry, together with the importance of chemical manufacture, was given by Dr. J. T. Brogden, member of the American Chemical Society.

Gabriel R. Solomon, member of the American Society of Civil Engineers and of the Engineering Association of the South, then read a paper on the necessity for the engineer in public service, in which he said that the lack of recognition of the engineer by the public was largely his own fault because he is an indifferent citizen. The engineer needs to get into touch with life and to cease to hold himself aloof from public affairs while there are public questions of engineering interest which await an expression of intelligent and trained opinion.

Short talks were also given by Frederick Kloepper, of the American Institute of Architects, Prof. H. P. Wood, member of the American Institute of Electrical Engineers, R. D. Kneale, associate professor of civil engineering of the Georgia School of Technology, and Dan Cary, superintendent of parks and playgrounds. The last speaker laid stress on the necessity of expert advice in connection with city planning.

## ST. LOUIS, OCTOBER 28

At a meeting of the Associated Engineering Societies of St. Louis, held on October 28, under the auspices of the local section of the Am.Soc.M.E., John Hunter gave a very interesting paper on The Development of the Central Station. The paper was illustrated by lantern slides, showing central stations in Boston, New York, Albany, Philadelphia, Detroit, Milwaukee, Chicago and St. Louis. The paper was discussed by those present.

## BUFFALO, NOVEMBER 5

At a meeting of the Buffalo Engineering Society on November 5, J. Irvine Lyle of New York addressed the society on Industrial Ventilating and Cooling Equipment. Mr. Lyle gave some very interesting facts regarding some recent installations in cotton mills, tobacco manufacturing plants, automobile plants, etc., for the purpose of air conditioning. His address was illustrated by lantern slides showing the construction and arrangements for the distribution of the pure air. There were about 120 members present.

## NEW HAVEN, NOVEMBER 18

The Fall Meeting in New Haven was held at the Mason Laboratory of Mechanical Engineering, Sheffield Scientific School, on November 18. The following papers were presented: Electricity in Industry by Prof. Charles F. Scott, and Motor Applications; Arc Welding; Heat Treatment by W. L. Merrill of the General Electric Company. Following the presentation of the papers were a number of short addresses on applications of electricity by local manufacturing companies. The speakers were Mr. Flynn of the Royal Typewriter Company of Hartford on the Use of Electricity in Japanning Kilns, and Charles R. Underhill of the Acme Wire Company, New Haven, on the Use of Electromagnets in Manufacturing. W. S. Huson of Derby and C. H. Norris of New Britain discussed the papers.

Immediately after the afternoon session, there was an interesting demonstration in the laboratory of the variable speed hydraulic transmission manufactured by the Waterbury Tool Company of New Britain. This exhibit was arranged by courtesy of the Yale University Student Branch of the Society. Reynold Janney was in charge of this feature of the meeting.

J. Arnold Norcross was the Chairman of the evening session. Calvin W. Rice, Secretary of the Society, gave a talk on the Society and its work. The principal paper of the session was by S. S. J. Worgan of the Westinghouse Company on The Electric Motor in Manufacturing Plants. Short addresses were made by Prof. Scott, W. N. Polakov of the N. Y., N. H. & H. R.R. Company and Mr. Vandervere of the New Haven Gas Light Company and several others. The registration at the session was 150.

## BOSTON, NOVEMBER 18

At a joint meeting of the Society with the Boston Society of Civil Engineers and the American Institute of Electrical Engineers on November 18, Henry M. Waite, city manager of Dayton, Ohio, gave an address on the new Commission-Manager Form of City Government.

He criticized at the outset the older federal form of city organization, and said that before a new system could be introduced the grasp of professional politicians must be loosened and ward and precinct organization relegated to the past. He called attention to the necessary allegiance of the political appointee to his political machine and the popular belief that the mayor and his administration should be blamed for all shortcomings, even though the chief executive were tied hand and foot and shorn of administrative power.

In Dayton, politics and municipal affairs had been divorced. Five commissioners were elected last November, all of whom are business men. This commission appointed a city manager and it is in the manager's power to appoint the five directors of law, finance, welfare, safety and service.

## BUFFALO, NOVEMBER 19

At the meeting of the Buffalo Engineering Society on November 19, Prof. Dexter S. Kimball, professor of machine design and construction at Cornell University, addressed the Society on Appearance as a Factor in Design. Professor

Kimball treated his subject along broad lines, free from technicalities. There was an attendance of about 130 at the meeting.

### CINCINNATI, NOVEMBER 19

At a joint meeting with the Engineers' Club of Cincinnati on November 19, Fred A. Geier, Associate Member of the Society, spoke on The Development of the Machine Tool Industry in Cincinnati. He traced the begininng of the industry to John Steptoe, who in 1850 built the first machine tool in Cincinnati. To Mr. Steptoe must be given the credit of having laid the foundation of one of the most important industries of Cincinnati, which has placed Ohio first in the production of machine tools. The second firm to install a department of machine tools was that of Niles and Company in 1865. This firm later developed into the Niles Tool Works and moved to Hamilton, Ohio. George Gray of this company remained in Cincinnati, however, and continued the manufacture of planers.

The speaker then outlined the conditions that make Cincinnati a good center for the manufacture and distribution of machine tools. He gave estimates of the volume of business at the present time, the number of men employed and the possibilities of development in the future.

### ST. PAUL, NOVEMBER 19

A meeting of the Minnesota Branch of the Society was held at St. Paul on November 19. V. H. Roerich, City Chemist presented a paper on Coal Testing. The paper aroused considerable enthusiasm and discussion.

### CHICAGO, NOVEMBER 20

The Chicago Section held its first meeting of the season on November 20. There was an informal dinner at which 140 were present. W. H. Winslow, the first speaker, explained the construction and operation of his new high-pressure boiler. He touched upon the possibilities of high pressures and of the Stumpf una-flow engine, which appears to be the prime mover best adapted for high pressure and super heat. His talk was illustrated by lantern slides.

Henry A. Allen, consulting engineer for the City of Chicago, and Robert Cramer, engineer of the Winslow Company, discussed the paper. Mr. Allen believed that the new boiler was specially adapted for portable use, such as for automobile trucks or buses and the large traction plow. Mr. Cramer believed that this boiler would soon be used by the largest power plants of the country and would show results at least 12 per cent higher than the best obtainable today.

The subject of boiler efficiency meters and European boiler practice was presented by W. A. Blouck, maker of the boiler efficiency meter. He explained briefly the principles of his meter with the red and blue fluids showing the drop in draft through the furnace and setting respectively. Mr. Blouck then spoke of European boiler practice. By means of slides, he showed the fine architectural design of the buildings and the efforts made to add to the appearance of the stack. Cross-sectional views showed the design generally followed and the small bunker capacity for coal. The latter was stored on the ground and conveyed to the boiler as needed. The injector draft chimney was in frequent evidence and ash-handling facilities were a negative quantity due largely to cheap labor. Small steam pipes with velocities up to 14,000 ft. per minute were also a feature.

The last part of the talk was devoted to the high-duty boiler with built in economizer. Evaporation tests of this kind of a boiler at Hamburg were presented. Joseph Harrington discussed some of the advantages of the German boiler, but he was of the opinion that the Blouck meter was very accurate and should be of great value in the boiler room.

Walter H. Green, chief engineer of the International Filter Company, spoke on mechanical filters, dwelling on methods of rating and some of the experiences that his company has had with prospective customers. Reference was made to the tendency of installing filters that were too small and also to the matter of using sand or quartz in the filter. Either may be used, but sand may be used in its natural state, whereas quartz must be ground. If sand is used, however, careful attention must be given to the choice of the sand, as it is quite essential that the particles be of uniform size.

### PHILADELPHIA, NOVEMBER 21

A joint meeting with the Engineers' Club of Philadelphia was held on November 21. F. C. Hubley, Assistant Engineer of the American Bridge Company, gave a paper on Bituminous Coals; Predetermination of their Clinkering Action by Laboratory Tests. In a search for a specification that would really tell the operating properties of coal, the author discusses the clinkering of coal, which, as he shows, materially affects the capacity and efficiency of the plant, the amount of labor spent in cleaning fires and upkeep of fire boxes, and the smoke generation. The delays due to excessive clinkering may sometimes offset the advantage of a lower price of the coal. In order to specify the clinkering of coal in purchase contracts, however, a clear comprehension of this property has to be worked out, and methods developed for its laboratory determination, and the author shows that the former is possible by determining not the "fusible point" which, with a complex mixture such as coal ash, cannot be well defined, but the "fusible range" which is capable of precise definition and exact determination. He then proceeds to describe various methods of determining the fusing point of ash, such as the cone method, the fusiometer method, etc. He shows also that there is always a point capable of definite recognition in the fusing range, which although not the fusing temperature in the ordinary sense, is nevertheless a stage past that of incipient fusion and that this point of temperature bears a direct relation to the clinkering temperature in a boiler furnace, while the nature of the clinker formed, whether porous or spongious or close and hard, has as much to do with the detrimental effect on boiler operation as the question of temperature of formation. Fusing points were plotted against combination of the ash constituents so as to determine a relation between the approximate fusing point and the presence of two or more of the ash elements as determined by chemical analysis.

This very important subject was discussed by A. C. Wood, Professor Fernald, W. H. Fulweiler, E. M. Nichols, Dr. H. M. Chance, F. C. Freeman, Mr. Clonnell and E. B. Carter.

### BUFFALO, DECEMBER 3

Ellis L. Howland addressed the meeting of the Buffalo Engineering Society on December 3, on the subject Practical versus Theoretical Ideals in Motor Truck Installation. Mr. Howland is automobile editor of the *Journal of Commerce* of New York City and he treated his subject from

the users or commercial standpoint and not from an engineering standpoint.

H. B. Alverson of the Cataract Power and Conduit Company and First Vice-President of the Engineering Society of Buffalo was in charge of the meeting. There were about 170 present.

### SAN FRANCISCO, DECEMBER 8

At a meeting in San Francisco on December 8, the paper of the evening was read by A. H. Babcock, consulting electrical engineer for the Southern Pacific Company, on A Rational Method for the Treatment of Boiler Feed Water. Mr. Babcock described in detail the remarkable results that had been achieved in the treatment of the boiler feed water used at the Alameda power station for the Southern Pacific Company's suburban trains.

Mr. Geibel, who is Mr. Babcock's assistant and who is in direct charge of the experimental work showed in detail the methods that were pursued in overcoming the corrosive effect of waters carrying a large percentage of alkalinity, and also methods of testing the feed water for determination of the new treatment and the apparatus used for this purpose.

Mr. Twogood and Mr. Partridge also spoke briefly on the subject. The meeting was then open for discussion.

### BOSTON, DECEMBER 9

At a local meeting in Boston on December 9, Mr. Nunez gave a paper on the Technology of Paper Making. In this paper, Mr. Nunez traced the different processes in the manufacture of paper and the different materials from which paper has been made from the time when it was first invented by the Chinese to the present time. He then discussed the quality, kinds, consumption and uses of paper. Paper is an extremely important article of commerce and has innumerable uses. The quality of any paper depends upon the use to which it is to be put, but the qualities which have to be considered and which govern its value for use are: strength, bulk, fibre direction, formation, finish, feel, texture, rattle, sizing, opacity, color, printing, erasing qualities, expansion and contraction, fibre composition, chemical residue and durability.

## NECROLOGY

### EDWARD DANIEL MEIER

In the death of Col. Edward Daniel Meier on Tuesday, December 15, 1914, after several months of illness, the engineering profession has lost one of its most honored members. He was president and chief engineer of the Heine Safety Boiler Company, president of The American Society of Mechanical Engineers in 1911, and for 20 years was one of the most active workers in the Society. He enjoyed an unusually wide circle of friends, as evidenced by the presentation at the Pittsburg meeting of the Society of an engrossed testimonial by a large number of his fellow members in celebration of his seventieth birthday.

He was born in St. Louis, Mo., May 30, 1841. At the close of a scientific course at Washington University, St. Louis, in 1858, he spent four years in Germany at the Royal Polytechnic College in Hanover, this being followed by an apprenticeship at Mason's Locomotive Works, Taunton, N. J. In 1863 he enlisted in the Grey Reserves, the Thirty-Second Pennsylvania, which was attached to the army of the Potomac until after the Battle of Gettysburg. He subsequently served in the Second Massachusetts Battery, also in the United States Engineer Corps, and finally became lieutenant in the First Louisiana Cavalry, seeing much active service, and on May 30, 1865, receiving the surrender of Lieutenant-General John B. Hood and staff.

At the close of the war he entered the Rogers Locomotive Works, at Paterson, N. J., remaining one year. From 1867 to 1870 he was associated with the Kansas Pacific Railway, first as assistant superintendent of machinery, keeping open its Western communications when the bridges were swept away, designing, building and operating a mill for sawing, planing and turning the soft magnesian limestones by machinery, designing machine and car shops, etc., and subsequently becoming superintendent of machinery. He resigned to become chief engineer of the Illinois Patent Coke Company, leaving there in 1872 to assume the secretaryship of the Meier Iron Company and to build its blast furnaces. From 1873 to 1875 he directed the machinery department of the St. Louis Interstate Fair. During this time he became actively interested in the St. Louis cotton industry and was associated with the St. Louis Cotton Factory and with the Peper Hydraulic Cotton Press, for both of which he designed machinery for compressing cotton. In 1884 he organized the Heine Safety Boiler Company for the development in the United States of the water-tube boiler of that name, and continued as its president and chief engineer to the time of his death. He was also responsible for the introduction of the Diesel motor into the United States and until 1908 was engineer-in-chief and treasurer of the American Diesel Engine Company. One of his most important accomplishments was the design and installation of 10,000 h.p. boilers in the power house of the new Grand Central Terminal, New York.

Colonel Meier was lieutenant-colonel and later colonel of the First Regiment of the Missouri National Guard, serving about ten years, and was a member of the Grand Army of the Republic and of the Loyal Legion. He had been active in a number of professional organizations, serving in 1881-1884 as treasurer of the St. Louis Engineer's Club, in 1889-1890 as its president, and as secretary of the American Boiler Manufacturers Association. It was in the latter capacity that he drew up the Uniform American Boiler Specifications of 1898. He had been president of that organization and also of the Machinery and Metal Trades Association.

In The American Society of Mechanical Engineers, which he joined in 1891, he was active on many committees. He served as manager from 1895 to 1898, twice as Vice-President, from 1898 to 1900 and from 1909 to 1910, and as President in 1911. At the time of his death he was a member of the committee of the Society to formulate Standard Specifications for Steam Boilers, which had its inception largely through his efforts and which has accomplished a vast amount of work during the past three years.

A source of the greatest satisfaction to Colonel Meier, and a delightful memory to his many friends, was his connection with the remarkable tour through Germany in the summer of 1913 at the invitation of the Verein deutscher Ingenieure. Colonel Meier was chairman of the committee hav-

ing all the arrangements in charge, to a considerable extent was conductor of the party and many times was its spokesman. He often addressed his audience in German and his intimate knowledge of German history and accomplishment and his thorough appreciation of the industrial ideals of the nation added materially to the value and pleasure of the trip to the large number of engineers and guests who constituted the party.

#### AXEL H. HELANDER

Axel H. Helander was born in Vingaken, Sweden, in 1864, but came to America as a boy and spent most of his life in Pittsburgh. From July 1, 1906, to September 30, 1912, Mr. Helander was connected with the engineering department of the Mesta Machine Company after which he was with the William Tod Company, of Youngstown, Ohio, as second vice-president and general sales manager. Mr. Helander was the designer and inventor of many important engineering devices, chief among which might be listed the Helander condenser. He died at his home in Youngstown on October 17.

## PERSONALS

Jay G. DeRemer has accepted a position with the American District Steam Company, North Tonawanda, N. Y. He was until recently affiliated with the United Light and Power Company, San Francisco, Cal., as chief engineer.

Ruland R. Shafter has accepted a position with the Chester Steel Castings Company as their New York manager.

Julius G. Berger has become connected with the Fulton Light, Heat and Power Company, Fulton, N. Y., as engineer.

Nicholas S. Hill, Jr., consulting engineer, has formed a partnership with Smith Farley Ferguson, and will continue to practice with him as a consulting hydraulic and sanitary engineer, under the firm name of Nicholas S. Hill, Jr., and S. F. Ferguson.

M. C. Maxwell, for the past seven years head of the Department of Applied Mechanics at Pratt Institute, Brooklyn, N. Y., and a Consulting Engineer, became identified with the Yale and Towne Manufacturing Company of Stamford, Conn., on July 1, 1914. He is now Superintendent of Power and Plant of that company, and is responsible for the power generation and distribution, the building maintenance, all new building construction, the general repairs and maintenence of all machinery, shafting, etc., throughout the plant. He also has charge of the tool department and is responsible for all tool designing, the machine shops for building tools, jigs, fixtures, dies, gages, etc., and the forge shop.

E. L. Hill has recently accepted a position with the Hazard Manufacturing Company at Wilkesbarre, Pa., in the capacity of Consulting Engineer and assistant to the Management. He was formerly with the American Steel and Wire Company, and for the past four years was superintendent of the company's insulated wire and power cable plant at Worcester, Mass.

Daniel W. Mead, having been absent from the United States during the summer as a member of the American National Red Cross Board of Engineers-Chinese River Conservancy, wishes to announce that he has returned, and is now prepared to serve his clients in making examinations, reports, plans and specifications for water power, water supply, flood protection, drainage irrigation, power plants and power transmission installations.

Dr. George F. Swain, Professor of Civil Engineering at Harvard University, delivered a lecture on Laws Hamper Improvement of Resources before the Technology Club of Syracuse on December 2. This was one of the series of lectures by prominent men which are called the "John E. Sweet Lectures" in honor of the Club's first President.

J. H. Dougherty, formerly with the International Steam Pump Company, has been engaged by the Northern Equipment Company to take charge of the centrifugal pump design and the improvement and development of the well-known line of Erie Centrifugals.

Prof. C. R. Richards, Acting Dean and Director of the College of Engineering and Experiment Station of the University of Illinois, announces that there will be four vacancies for research fellowships to be filled at the close of the current academic year. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments to these fellowships are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the Master's degree will be granted. Not more than half of the time of the Research Fellows is required in connection with the work of the Department, the remainder of the time being available for graduate study. Applications must be made not later than February 1 to the Director of the Station. Appointments are made in March and they take effect the first day of the following September.

Leo Loeb has been transferred from the Engineering Experiment Station at Annapolis, Md., to the Post Graduate Department of the United States Naval Academy at Annapolis, as professor of marine engineering.

Anderson Polk announces the opening of an office as testing and inspecting engineer, specializing in protective coatings and paint problems, with facilities for testing and analyzing cement, brick, iron, steel, paints and varnishes, waterproofing and all building construction materials.

James E. Allison, Chief Engineer of the St. Louis Public Service Commission, has been appointed as lecturer in Economics at Washington University. The lectures will deal with the economic principles underlying the regulation of public utilities. Some of the specific problems to be studied are the organization and operation of public utility corporations, their securities and the methods of financing them, and especially the method of valuing public utility properties for the purpose of taxation and rate regulation. Seniors in the Engineering School will be required to take this course. In order to encourage further the study of economics by the students, Mr. Allison has established a fund to be known as the "Allison Fund," the annual income of which is to be used either for awarding cash prizes or in such manner as in the opinion of the Dean of the School of Engineering and the head of the Department of Economics will best promote the object of the fund.

## STUDENT BRANCHES

#### ARMOUR INSTITUTE OF TECHNOLOGY

On December 2, the Armour Institute of Technology Student Branch held its third meeting. Frederick Purdy, factory engineer for the Rayfield Carburetor Company gave a talk on Carburetion. Starting with the primitive carburetor of the surface type, Mr. Purdy showed the advance that has taken place by means of working models and slides. A number of curves from carburetor tests served to show the effect of various adjustments on the carburetor.

#### CARNEGIE INSTITUTE OF TECHNOLOGY

The regular monthly meeting of the Carnegie Institute of Technology Student Branch was held on November 11. After the regular meeting, the Mechanical and the Mho Clubs were jointly addressed by Mr. Hood of the mechanical engineering department of the Bureau of Mines. In a short time, the Bureau which will coöperate closely with the Institute in its work, expects to open its new buildings near the school.

In these buildings, will be located a mining, a mechanical engineering, a chemical, a miscellaneous mineral, a petroleum and an administrative department. In outlining the work of the Bureau, Mr. Hood said: "It shall conduct inquiries and scientific and technologic investigations concerning mining and preparation, treatment, and utilization of mineral substances with a view to improving health conditions and increasing safety, efficiency, economic development and conserving resources through the prevention of waste in the mining, quarrying, metallurgical, and other mineral industries; to investigate explosives and peat; and on behalf of the government to investigate the mineral fuels and unfinished mineral products belonging to, or for the use of the United States, with a view to their most efficient mining preparation, treatment and use; and to disseminate information concerning these subjects."

### CASE SCHOOL OF APPLIED SCIENCE

At a meeting of the Student Branch of the Case School of Applied Science, a paper was presented by A. P. Armington, '15, on Efficiency Engineering. Three methods were taken up in detail and illustrated by examples: 1. Direct office control of production; 2. Time keeping with use of lapse time recorders; 3. Piece work systems and method of calculating rates. A discussion followed the presentation of the paper.

### COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on November 23, Prof. C. E. Lucke gave a lecture on Surface Combustion explaining its theory and design problem and showing the commercial advantage of this process of heating.

At a meeting on December 11, Arthur V. Fair of the S. F. K. Ball Bearing Company gave an interesting lecture on the Present Day Application of Ball Bearings. He spoke of the method of manufacturing and assembling ball bearings, their lubrication and care, the method of mounting them and their application to numerous industries such as the textile, machine tool, motor, locomotive, steel car, steel mill and automobile.

### CORNELL UNIVERSITY

A meeting of the Student Branch of Cornell University was held on November 18. Prof. R. C. Carpenter spoke on the necessity for research in making possible the practical application of scientific theories and knowledge and the need of the college not for the spirit of research but for equipment upon which that spirit might work for beneficent end.

Prof. A. W. Smith, Dean of the College, spoke informally on the founding and ideals of the Am. Soc. M.E. and the mutual benefits enjoyed by the Society and its members.

At a meeting on December 16, Prof. D. S. Kimball lectured on primitive and recent mining machinery and methods. He spoke in particular of those in use in the development of the deep mines at Virginia City, Nev.

### KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch on November 3, Professor Schluss gave an interesting paper in which he discussed some of the problems met with in the design of governors and the operation of different types of governors. Floyd Pattison, a graduate student, discussed the operation and manufacture of gas producers and emphasized many of the operation troubles of a producer gas plant.

At a meeting held December 3, Mr. Hinman of the apprentice department of the Santa Fe Railway System discussed the efficiency movement and the wide field where efficiency could be practiced. Mr. Hinman discussed in detail the necessity of coöperation of all employees for the best results and the advantages and disadvantages of day wages, piece work and the bonus system. In conclusion, he gave an outline of the apprentice school and its advantages to the men in the shops and to the employer.

W. W. Haggard, a student, read a paper which gave a detailed description of the Dynamometer Car used by the Santa Fe Railway, the chronograph and records, and the way these records were taken and worked up by the office force.

### LEHIGH UNIVERSITY

On November 10, the Student Branch of Lehigh University held a meeting at which the following papers were read: A Summer in the British Isles by D. Davidson '15 and Mechanical Engineering of Anthracite Coal Mines by W. H. Lesser, mechanical engineer for the Philadelphia and Reading Coal and Iron Company at Pottsville, Pa.

### LELAND STANFORD JR. UNIVERSITY

At a meeting of the Leland Stanford Jr. University Student Branch on November 12, G. W. Dickie, Consulting Naval Engineer in San Francisco delivered a lecture on Safety at Sea. Mr. Dickie laid great emphasis on the importance of stability in steamship design.

### OHIO STATE UNIVERSITY

On November 13, Edward P. Roberts, M.E. of the Roberts and Abbott Company, Consulting Engineers, Cleveland, Ohio, also Smoke Commissioner in the Department of Public Safety of that city, addressed the members of the student branches of the A.S.M.E. and the A.I.E.E. on the subject of Smoke Abatement.

Mr. Roberts discussed the various types of boiler settings for both the water tube and fire tube boiler and showed several arrangements that he had found to be very successful and comparatively cheap to install. He stated, however, that a setting which might give very complete and smokeless combustion under one set of conditions, might be wholly unsatisfactory if used under slightly different conditions, and emphasized the point that each case had to be dealt with separately. He named the requisites for complete combustion and then showed how the designers of the various types of stokers upon the market today had endeavored to make their stoker embody these principles.

The speaker gave figures showing the enormous losses which Cleveland and Pittsburgh attributed to the smoke nuisance, Cleveland's loss according to the 1908 report being $6,000,000 or $44 per family. This does not include the loss to plant and animal life, or the effect upon the respiratory organs of the people. He explained the methods used by the smoke inspectors of Cleveland in finding the offenders and the methods used in dealing with them, also the results of their work showing the great improvement they had effected in the abatement of the smoke from railway and yard locomotives. Mr. Roberts stated that the abatement of smoke was a problem well worth considering by all large cities, both from an economic and engineering standpoint. He claimed that the Cleveland department was paying several thousand per cent on the money invested in it.

The lecture was illustrated by lantern slides.

At a meeting on December 15, S. J. Lauer presented a paper on A Comparison of the Six-cylinder versus the Eight-cylinder Motor Car Motor. H. S. Vine gave a paper on The Oxy-acetylene Process of Welding. There was no discussion.

### STEVENS INSTITUTE OF TECHNOLOGY

The Student Branch of Stevens Institute of Technology held its first lecture for the school year on December 8. Prof. William Kent, an alumnus of Stevens, a member of the American Society of Mechanical Engineers and a compiler of the well-known Handbook for mechanical engineers, gave a very interesting talk on Common Sense and Engineering, illustrating his subject with numerous appropriate stories. The meeting was especially honored by having two other prominent men in the American Society of Mechanical Engineers and in the engineering world, as speakers. Dr. Humphreys, President of Stevens Institute of Technology, gave a short prelude to the lecture by speaking of the engineer's place in the business world, while C. W. Rice, Secretary of the American Society of Mechanical Engineers, said a few

words on the Society's branches among students and the way in which they could be strengthened.

### THROOP COLLEGE OF TECHNOLOGY

The first regular meeting of the Throop College of Technology Student Branch was held on December 18. C. H. McQuire, representative of the Los Angeles Branch of the Busch Sulzer Diesel Engine Company, spoke on the Diesel Engine. Lantern slides were used to illustrate his talk.

### UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held a meeting on November 28, at which D. J. Durrell, master mechanic of the Pennsylvania Railroad, gave a talk on the duties of the mechanical engineer, what conditions a mechanical engineer must face upon graduation, railroad work as applied to mechanical engineering and some of Mr. Durrell's experiences in that profession The first two points the speaker discussed in detail and in the discussion of the third point, he included a brief history of the locomotive regarding its weight and its ability to devour space, also a summary of the transportation units and the traffic of the Pennsylvania Railroad during the year 1913-1914.

Prof. J. T. Faig, honorary chairman of the student branch, gave a short extemporaneous talk in which he pointed out the analogy of some of the speaker's remarks and his own teachings.

### UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Branch was held on December 10. Charles M. Hampson, a consulting engineer from Colorado and a member of the Am Soc. M. E., delivered a lecture to the students on the ethical side of engineering, or as he said that he liked to call it, the "side of the square deal." In tracing the growth of the profession, he showed that the responsibilities of the mechanical engineer of today are much greater than those of the mechanical engineer in the earlier days of the profession.

### UNIVERSITY OF KENTUCKY

The first regular meeting of the University of Kentucky Student Branch was held on November 28, at which the following officers were elected: Minott Brooke, president; Y. B. Arnold, vice-president; P. T. Taylor, treasurer, and T. R. Munson, secretary.

Prof. F. P. Anderson, Dean of the College of Mechanical and Electrical Engineering, spoke on the relation of the branch with The American Society of Mechanical Engineers and the advantages of the young engineer by belonging to the Society.

On November 4, Dr. A. S. McKensie, Dean of the Graduate School, spoke to the branch on the value of research work to the engineer.

### UNIVERSITY OF MAINE

At a meeting of the University of Maine Student Branch on December 17, four reels of moving pictures which belonged to the National Tube Company showed the ore as it was taken from the mines in the Lake Superior region, its transportation to the company's factories and the different processes through which it goes before it finally becomes the tube product.

### UNIVERSITY OF MICHIGAN

A meeting of the University of Michigan Student Branch was held on December 5. F. R. Still of the American Blower Company gave a short talk on The Application of Blowers to General Engineering Practice which included the ventilation of public buildings, the necessity of humidifying the air in such buildings for the health of the inhabitants, a process of air drying which is being tried in the west on some of the fruits instead of the regular sun drying, and a continuous process for manufacturing of bricks which has proved successful on a great many kinds of brick.

Mr. Still showed slides illustrating different types of blowers and their various applications, also some curves from which these fans are designed to meet the requirements.

### UNIVERSITY OF MINNESOTA

At the November meeting of the Student Branch of the University of Minnesota, Prof. C. F. Shoop of the Department of Experimental Engineering was selected to Honorary Membership.

Messrs. C. J. Snow and E. H. Roberts presented papers on the Heating and Ventilating of the New Saxe and Shubert Theaters. The Saxe Theater, a motion picture house with a seating capacity of 1400 is heated and ventilated by the plenum system. The fresh air is taken in at the roof level, and taken down a vertical shaft from which it passes through the temperature coils which consist of 918 sq. ft. of "Vento" heaters, arranged two stacks deep and two tiers high. It next passes through the air washer which is of the "Webster" make, and from there through the re-heating coils which consist of 1836 sq. ft. of "Vento" heaters arranged four stacks deep and two tiers high. The air is then drawn through the fan and from there is sent to the distributing branches. The building is provided with automatic temperature and humidity control, making the plant entirely automatic. Steam is purchased from an outside source at the rate of $.55 per 1000 lb. of condensate.

The Shubert Theater heating plant consists of a low pressure steam heating plant and plenum system of ventilation. The heating system consists of 66 ft. by 16 in. tubular boiler, on a two pipe steam system with 560 sq. ft. direct radiation. The ventilating system consists of a 60 in. steel plate fan, directly connected with a 10 h.p. motor running at 250 r.p.m. Air is drawn from street level through a bank of coils containing approximately 4000 lineal ft. of 1 in. pipe, which is equivalent to 1561 sq. ft., having free area of 23.1 sq. ft. Air is discharged into a large plenum chamber extending under the greater part of the auditorium. From here it goes directly into the auditorium through about 400-9 in. by 6 in. openings with hoods, so that the discharge is parallel to the floor. Exhaust is by means of natural draft. The peculiarities of the plant are that the air velocity is reduced both in coils and chamber, and dust is thus eliminated without special apparatus. The efficiency figured on a B.t.u. basis is 67 per cent, exclusive of boiler.

At the December meeting of the branch, M. E. Crosby gave a general outline of the flour industry. He traced the wheat through the different processes which it undergoes from the time it enters the mill until it is turned out as one or more different grades of flour.

In conjunction with Mr. Crosby's talk, A. P. Mason gave a description of a grinding machine which is used to grind screenings. The principal feature of this machine is a perforated cylinder of hardened steel against which the stock is thrown tangentially at the high velocity. A shearing effect is thus produced which reduces the stock to the desired size.

### UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch on December 3, Messrs. Haney and Royse were appointed to investigate affairs pertaining to the society's proposed inspection trips to St. Louis, Mo., and other nearby cities.

Ralph Coatsworth read a paper on the new 8 cylinder "V" type internal combustion motor which is now used by the Cadillac Motor Company.

### UNIVERSITY OF NEBRASKA

At a meeting of the University of Nebraska Student Branch on December 1, Prof. B. F. Raber of the Department of Mechanical Engineering who spent the summer in the turbine department of the Westinghouse manufacturing plant at Pittsburgh, Pa., gave an illustrated lecture on the Pittsburgh District.

The town proper is located at the point which is formed by the junction of the Allegheny and Monongahela Rivers, and the district includes the area within a radius of about forty miles of this point. The country is very hilly and the flood plains of the rivers are bordered by high cliffs. On account of the rugged nature of the country, the district is divided into an enormous number of small towns and cities.

The mills that are scattered through the country and along the rivers together with their employees form towns by themselves. One of the largest of these outside of Pittsburgh proper is Wilkinsburg, where most of the Westinghouse employees make their homes. It has a population of about 20,000. Other large and thickly populated parts are So. Pittsburgh which is across the Monongahela River from the Point and Allegheny which is across the Allegheny River from the Pittsburgh District. The population of the Pittsburgh District is over 4,000,000.

Professor Raber gave views of Pittsburgh showing the business and residence districts, wharves, private residences, parks and the buildings of the University, including the exterior and interior of the Carnegie Institute and School of Technology. He showed some views of places outside of Pittsburgh proper which included all of the larger steel and iron mills, the plants of the American Signal Company and the Westinghouse Company. He described their products, the number of employees and the pay roll. The turbines and engines of the Westinghouse type were shown both complete and in course of construction. One of these was being built for the U. S. S. "Neptune."

#### WORCESTER POLYTECHNIC INSTITUTE

At the meeting of the Worcester Polytechnic Institute Student Branch on December 4, H. Clayton Kendall of the Rockwood Sprinkler Company gave an illustrated lecture on Factory Fire Protection. After a brief review of the amount of property loss by fire, the speaker described the mechanical means taken to put water on a fire in its incipient stage. The foremost mechanical device at the present time for doing this according to Mr. Kendall is an automatic sprinkler head kept properly supplied with pressure water. In the lantern slides shown by Mr. Kendall, the effect of an automatic sprinkler system as preventing serious conflagrations in buildings thus equipped was clearly presented.

#### YALE UNIVERSITY

A meeting of the Yale University Student Branch was held on November 13. At this meeting, Reynold Janney, Vice-President and Chief Engineer of the Waterbury Tool Company, presented an illustrated paper on the Hydraulic Variable Speed Gear manufactured by the company with which Mr. Janney is connected. Mr. Janney's address was divided into three parts as follows: a. the advantages or practical aspect; b. the mechanical construction; c. the mathematical problems connected with the gear.

After the lecture, Mr. Janney demonstrated one of the gears which was mounted, together with its motor as a single unit.

## EMPLOYMENT BULLETIN

**Note: In sending applications stamps should be enclosed for forwarding.**

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

#### POSITIONS AVAILABLE

1201 Representatives wanted in the principal cities of United States to sell vacuum heating specialties on commission. Apply through Society. Applicant will please state what similar specialties, if any, he has previously sold.

1202 Several good draftsmen—salaries $100 to $125 per month. Location South Bethlehem, Pa.

1203 Superintendent and master mechanic, man of refinement, preferably graduate of M.I.T., with textile mill experience, and one who can take a position of prominence in company and city. Salary about $2500. Age 30 to 35. Apply through Society.

1204 New England University desires assistant to the instructor in charge of the mechanical laboratory and in correcting of problems in thermodynamics, mechanism, and machine design. Desires a man with initiative and a desire to make good.

1206 Assistant in the boiler insurance department of a casualty and surety company; salary $1200 per year to start with reasonable expectation of steady advancement; essential requirements, knowledge of engines and boilers and ability to conduct correspondence. Young man preferred. Location New York City. Apply through Society.

1239 Man capable of taking charge of the production of a manufacturing department; requires experience in stamping, drawing and forming of steel; other desirable qualifications are ability to meet men in trade and to estimate orders and handle correspondence. Location Connecticut. Apply through Society.

1253 High class man to represent a Michigan company in the City of New York; must show a splendid record in the selling end of the power plant field, have a thorough acquaintance with the consulting engineering profession and must be a high-class salesman in the full sense of the word. Apply through Society.

1254 Competent young man to fill the position of assistant superintendent in a shop where a variety of heavy machinery is manufactured. Name confidential. Apply through Society.

01 Two competent detail draftsmen; experience in sugar house work; must be rapid and accurate. Location New York. Apply through Society.

02 A good opening for an engineer thoroughly experienced in design and operation of hot bulb two-cycle oil engines. Should be familiar with both foreign and domestic practice. Location, Illinois. Apply through Society.

04 Large New Jersey plant wants a technical graduate, not over 30 years of age, to serve an apprenticeship and learn the technical and executive business of an important department, with a view, if successful, of becoming assistant superintendent. Give full statement of record, accounting for all of time since leaving college. Starting salary, $25.00.

07 Chief Draftsman, high grade practical machine designer, experienced in machine, pattern shop and drawing room; must be a man who can make practical designs from a shop standpoint, that goods may be manufactured cheaply and be of such grade as to meet the best competition. Position permanent for man of ability. Location, Missouri.

08 Young shop superintendent and engineer, one who has had considerable experience and is thoroughly familiar with machine work, and can also take charge of the drafting room, with ability to cut down manufacturing costs. Location, Illinois. Apply through Society.

#### MEN AVAILABLE

A-1 Junior member, age 25, experienced in factory work, machinist, tool and die-maker, designing of tools, machines, mill buildings, power plants and their equipment, also reports, factory accounting and reorganization, desires position in charge of production or in engineering department.

A-2 Mechanical engineer 1914 graduate with new untried idea for kerosene carburetor, desires position in experimental department of gas engine company willing to try out his idea.

A-3 Member, graduate engineer, experience as efficiency engineer, also design and supervision of installation of mechanical equipment of buildings, power plants and central heating systems, desires position with consulting engineer, architect or private concern.

A-4 Member, age 35, technical graduate, ten years experience in civil, mining and mechanical engineering, steel plant and general construction work desires executive or

sales position where broad experience, energy and tact will be required with good chance for advancement. At present employed.

A-5 Technical gradaute, Junior member, age 25, three and one-half years practical experience in engineering, desires position in selling department of manufacturing concern. At present employed in New York.

A-6 Associate, age 43, with wide manufacturing and considerable commercial experience would consider a position of responsibility in a large manufacturing concern or power company, or the general managership of a small growing company with good possibilities.

A-7 Member, graduate mechanical engineer, 20 years experience as designer and draftsman of simplex and duplex steam pumps, desires position as designer or chief draftsman.

A-8 Junior member, M.E., technical graduate, age 27, married, three years experience in drafting, machine design and laying out of hydro-electric plants, desires position with opportunity for experience and advancement. Location immaterial. At present employed.

A-9 Member, age 34, M.I.T. graduate, married, for past six years with leading engineers and architects in the East, designing steam power plants, heating and other piping systems and inspecting constructions and equipment, at present employed as superintendent on construction and equipment of large mill and power plant, desires position along similar lines.

A-10 Technical graduate, age 32, nine years experience in mechanical department of large western railroads as chief draftsman and mechanical engineer, three years as construction engineer and superintendent on power plant and shop construction. Has specialized in crude oil burning arrangements as applicable to locomotives and stationary boilers, shop, and power plant design, construction and equipment and electrical installations. Speaks Spanish; would consider foreign location.

A-11 Member, technical graduate, with commercial training, speaking five languages, fully conversant with Latin and South American trade conditions, 18 years varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines, testing and general plant engineering; familiar with handling men, drawing up contracts, purchasing equipment and material, appraising properties, modern methods of manufacturing and marketing products, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position. At present employed.

A-12 Member, wide experience in design and construction of factory buildings and power plants, purchasing of supplies and equipment for economical production, designing of special tools and machinery, has held positions as manufacturing superintendent, shop manager and chief engineer for large corporations, desires position with manufacturing or contracting company or firm of consulting engineers.

A-13 Associate-Member, engineering graduate, two years teaching experience, now employed as Diesel engine designer, wishes position of responsibility with manufacturers of oil or gas engines. Eastern location preferred.

A-14 Member, graduate of Stevens '97, broad experience in machine shop practice, superintendent of construction, field work, test of prime movers, boilers and power house design; for many years with leading consulting engineers and contractors in New York as designing engineer and draftsman, desires position of similar nature with engineering firm.

A-15 Engineer with experience in design and construction of special metal working machinery and tools for economic manufacture can offer an improved design of power punching and stamping presses in several sizes.

A-16 Member, Cornell graduate, mechanical and electrical engineer with extensive training and experience in designing, constructing, maintaining, operating and managing, desires a position as mechanical, electrical, efficiency or office engineer, superintendent, manager or purchasing agent of an engineering corporation.

A-17 Member of Society experienced in employment methods will take entire charge for large corporation hiring employees and supervising personal efficiency methods.

A-18 Member, Cornell graduate, fourteen years experience as machinist, material inspector, testing engineer, draftsman, mechanical engineer and salesman, desires position as sales engineer or engineering of tests. Location immaterial, western states preferred. At present employed as salesman of power plant machinery.

A-19 Mechanical engineer, Stevens graduate, age 30, married, six and one-half years varied experience, specialized in pressed steel, both light and heavy, at present holding responsible executive position as plant engineeer with small manufacturing concern, desires a position along similar lines, or one as assistant to superintendent or manager with company offering good chances for advancement.

A-20 Designing and contracting engineer desires to increase his clientele among concerns in need of engineering service in the field of machinery for the expeditious handling of materials of which he has made a specialty.

A-21 Junior, age 31, married, with 12 years experience in heating, ventilating and machine design, estimating, selling, complete knowledge of shop and office methods, capable of taking charge of designs and specifications wishes position with concern where efforts and loyalty are appreciated.

A-22 Member, M.I.T. graduate in mechanical engineering with post-graduate course in electrical engineering, twenty years experience in design and construction of machinery and building, manufacturing, systematizing, accounting, refrigeration and as consulting engineer, desires permanent position in New York.

A-23 Graduate mechanical engineer experienced in drafting, machine shop, foundry work and as a salesman, desires position with manufacturing concern in any department where there is opportunity for advancement.

A-24 Member, experienced in designing of locomotives and cars, specialized in efficiency work and the handling of men, expert examinations of property, desires position as manager of large manufacturing business.

A-25 Student member, age 23, technical graduate with shop and drafting experience, desires position.

A-26 Junior technical graduate in mechanical and electrical engineering, 12 years experience in design, construction, maintenance and operation of power houses and substations, high voltage transmission lines, design and erection of steam and water piping layouts, wiring and installation of machinery, pumps, engines, etc., desires position with large firm. Location New York. Salary $40.

A-27 Junior, graduate mechanical engineer with varied experience desires position with concern manufacturing or selling automobiles or automobile accessories. Willing to start as a demonstrator. Speaks German. Location immaterial.

A-28 Associate, age 40, Lehigh University graduate in mechanical engineering, 18 years experience in mechanical, civil and electrical work, including design, construction and operation of power plants, electric railway track work, industrial buildings, handling correspondence, purchasing, etc., for past seven years in responsible charge of work, wishes executive position of responsibility. Now temporarily employed.

A-29 Member, technical graduate, 16 years railroad experience in motive power department, including shops and

drafting room and mechanical engineering, desires similar position or one as assistant superintendent of motive power. Location immaterial.

A-30 Graduate mechanical engineer, three years practical experience in shop work, design, superintending, cost and sales work, and as head draftsman in engine and boiler works and shop superintendent in gasolene motor works. Moderate salary, location immaterial.

A-31 Junior, technical graduate in mechanical engineering, age 30, five years experience in mechanical and construction work, desires responsible position with manufacturing or construction firm.

A-32 Graduate mechanical engineer, four years practical experience desires position with manufacturing, engineering, contracting or consulting firm. Good future rather than salary considered.

A-33 Superintendent experienced in modern shop and manufacturing practice, good organizer who can produce interchangeable work at low cost and who understands cost keeping and the various systems of paying for labor.

A-34 Associate-Member having organization with several engineers, desires additional Chicago agencies in lines usually referred to architects and consulting engineers.

A-35 M.I.T. graduate in mechanical engineering, single, having specialized in the manufacture of raw and white sugar in the tropics; thorough knowledge of Spanish and tropical business methods. Now employed as chief engineer of large sugar house in the tropics.

A-36 Member, graduate M.I.T. in mechanical engineering, age 39, married, experienced in manufacture of ordnance-rifled arms, shell and ammunition, design and construction of dry docks—wood, stone and floating, pumping plants, power houses, and shops; acid and electrolytic refineries; wire and cable plants; reinforced concrete and general building construction with complete electrical and mechanical equipment for same; nine years general and seven years consulting engineering; position to be executive, superintendent or engineer of construction. Location preferred, Eastern Canada.

A-37 Mechanical and electrical engineer, with a number of years experience in installation and operation of power plant and factory equipments, building construction and maintenance of factories and buildings, is qualified by experience to serve as construction or operating engineer, superintendent of manufacture, or appraisal of power and manufacturing equipment. Permanent position desired, but will not refuse reasonable offer for temporary work.

A-38 Energetic young man, age 26, graduate M.E., three years experience, desires position in mechanical engineering line. Location immaterial.

A-39 Junior member, age 26, experienced in design, construction and operation of steam engines, boilers, refrigerating machinery and power plant accessories, recently employed on design of Panama Canal coaling stations, desires position.

## ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

AMERICAN BUREAU OF SHIPPING. Rules for Building and Classing Vessels. *New York, 1914.* Gift of American Bureau of Shipping.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS. Transactions, vol. 1913. *New York, 1914.* Gift of Institute.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Report (preliminary) of the Special Committee on the Construction of Steam Boilers and for their care in service.

——— Recommendations for a Model Engineers' and Firemen's License Law, a Model Boiler Inspection Law, and a Code of Practical Boiler Rules.

——— Recommendations of the Boiler Code Committee for a Model Stationary Boiler Inspection law, a Model Stationary Engineers' and Firemen's License law, and a code of practical rules. (Progress Report.) Gift of A.S.M.E.

AMERICAN TRADE INDEX, 1911-13. Domestic edition. *New York, 1913.* Gift of A.S.M.E.

BAYLOR UNIVERSITY. Annual Report of the President and Trustees, 1913-14. *Waco, Texas, 1914.* Gift of University.

CAMBRIDGE (MASS.) WATER BOARD. Annual Report, April 1, 1913-April 1, 1914. *Cambridge, 1914.* Gift of Cambridge Water Board.

CITY OFFICIALS OF THE UNITED STATES, 1914. Compiled by Engineering News. Gift of A.S.M.E.

EDWARDS'S 900 EXAMINATION QUESTIONS AND ANSWERS FOR ENGINEERS AND FIREMEN. *Philadelphia, 1912.*

ELEMENTARY ELECTRICITY AND MAGNETISM, Wm. S. Franklin and Barry Macnutt. *New York, The Macmillan Co., 1914.* Gift of Publishers.

An elementary textbook for schools of technology and colleges. Remarkably clear in language. W. P. C.

FILTERS AND FILTER PRESSES FOR THE SEPARATION OF LIQUIDS AND SOLIDS, from the German of F. A. Bühler. *London, 1914.*

FORMS USED IN CONNECTION WITH OHIO ELECTRIC LIGHT COMPANIES. Gift of L. B. Webster.

HAWAIIAN VOLCANO OBSERVATORY OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY. Report January-March 1912.

——— Special Bulletin. An address delivered at a meeting December 11, 1913, by T. A. Jaggar, Jr. 1913.

——— Weekly Bulletin, vol. 2, nos. 1-25, 1914. Gift of Massachusetts Institute of Technology.

HYDRAULIC TURBINES, R. L. Daugherty. ed. 2. *New York, 1914.*

INSTITUTION OF MECHANICAL ENGINEERS. General Index to Proceedings, 1901-1910. *London.* Gift of J. Inman Emery.

THE KELVIN LECTURE, S. P. Thompson. Delivered April 30, 1908. Gift of C. W. Rice.

MACHINE DESIGN, CONSTRUCTION AND DRAWING, H. J. Spooner. ed. 3. *New York, 1913.*

MATERIALS OF MACHINES, Albert W. Smith. ed. 2. *New York, 1914.*

MECHANISMS OF STEAM ENGINES, Walter H. James and Myron W. Dole. *New York, J. Wiley & Sons, 1914. Gift of Publishers.*

An elementary treatise on the kinematics of the steam engine for use by students. W. P. C.

MODERN FACTORY, Geo. M. Price. *New York, 1914.*

MOTORCYCLES, SIDE CARS AND CYCLE CARS, Victor W. Page. *New York, 1914.*

THE MOST IMPORTANT QUESTION OF THE AGE; IS THE EFFICIENCY OF A THERMODYNAMIC REVERSIBLE CYCLE INDEPENDENT OF THE WORKING MEDIUM, J. T. Wainwright. *Chicago, 1914.* Gift of author.

The Naval Constructor, George Simpson. A vade mecum of ship design. ed. 3. D. Van Nostrand Co., *New York, 1914.* Gift of Publishers.

This is the third edition of the author's work. It is replete with information of use to the naval constructor and contains much material which might be of great value to any engineer engaged in construction. The author has compiled much out-of-the-way information. W. P. C.

Niagara. State Reservation Commission. 30th Annual Report, 1912-13. *Albany, 1914.*

—— A History, by Chas. M. Dow. *Albany, 1914.* Gift of Commissioners of the State Reservation at Niagara.

Simeon North, First Official Pistol Maker of the United States, S. N. D. North and Ralph H. North. A Memoir. The Rumford Press, *Concord, N. H., 1913.* Gift of S. N. D. North.

Such monographs as this are too few in the United States; the majority of our people are too busy to make historical researches. Mr. North's record is very interesting, as bearing on the history of early American manufacturing. The Librarian wishes to thank the authors for this important contribution to a subject which has not received the attention it deserves. W. P. C.

Ohio Gas Light Association. Question Box. 19-22d Annual Convention, 1903-06. Gift of C. W. Rice.

Oil, Paint and Drug Reporter. Green Book for Buyers. September 1914 edition. *New York, 1914.* Gift of Oil, Paint & Drug Reporter.

Polyphase Currents, Alfred Still. ed. 2. *New York, The Macmillan Co., 1914.* Gift of publishers.

This is the second edition, largely rewritten and rearranged. W. P. C.

Practical Treatise on Milling and Milling Machines. *Providence, Brown & Sharpe Mfg. Co., 1914.* Gift of Publishers.

Published, not as a trade catalogue, but with the idea of presenting such information on the care and use of these machines as will be of assistance to beginners and practical men. There are extensive tables. W. P. C.

Primer of Scientific Management, Frank B. Gilbreth. *New York, 1914.* ed. 2. Gift of author.

The new edition is issued a little more than two years after the old one, showing a constant demand for an elementary treatise on the subject. W. P. C.

Pumping by Compressed Air, E. M. Ivens. *New York, 1914.*

Recall of Judges and Recall of Judicial Decisions. A discussion at the annual meeting of the Illinois State Bar Association. *Chicago, 1912.* Gift of Illinois State Bar Association.

Saw Mills, their arrangement and management, M. P. Bale. ed. 4. *London, 1914.*

Science of Knitting, Ernest Tompkins. *New York, 1914.*

Spur and Bevel Gearing. *New York, 1914.*

Surge Tank Problems, Franz Prasil. *Toronto, 1914.* Gift of E. R. Weinmann.

Testing of Wood Pulp, Sindall and Bacon. A Practical Handbook for the Pulp and Paper Trades. *London, 1912.*.

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# OFFICERS AND COUNCIL

**President**

John A. Brashear

**Vice-Presidents**

Terms expire December 1915
H. L. Gantt
E. E. Keller
H. G. Reist

Terms expire December 1916
George W. Dickie
Henry Hess
James E. Sague

**Managers**

Terms expire December 1915
Morris L. Cooke
W. B. Jackson
H. M. Leland

Terms expire December 1916
A. M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917
Charles T. Main
Max Toltz
Spencer Miller

**Past-Presidents**

Members of the Council for 1915

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Jesse M. Smith
James Hartness
Alex. C. Humphreys
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**Treasurer**

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**Honorary Secretary**

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**Executive Committee of the Council**

John A. Brashear, *Chairman*
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A. M. Greene, Jr.
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James E. Sague
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# STANDING COMMITTEES

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**Meetings**

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**House**

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## SOCIETY REPRESENTATIVES

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Alex. C. Humphreys, W. B. Jackson

**American Society Testing Materials Modification Briggs Standard for Pipe Threads**
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**Conference Committee on Electrical Engineering Standards**
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**Conservation**
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**Joint Committee International Engineering Congress 1915**
The President, The Secretary, C. T. Hutchinson, Thos. Morrin, T. W. Ransom, C. R. Weymouth

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**Standardization of Pipe and Pipe Fittings for Fire Protection**
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**Pan American Scientific Congress**
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**Registration of Engineers**
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**Cross-Section Symbols**
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**Research Committee, Sub-Committee on Steam**
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**Textiles**

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David Bell, *Chairman;* C. H. Bierbaum, C. A. Booth, S. B. Daugherty, Jas. W. Gibney

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Samuel G. Neiler, *Chairman;* H. M. Byllesby, *Vice-Chairman;* H. M. Montgomery, *Secretary;* P. A. Poppenhusen, H. S. Philbrick

**Cincinnati**

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**Los Angeles**

Walter H. Adams, *Chairman;* Ford W. Harris, *Secretary;* O. J. Root, W. W. Smith, Paul Weeks

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Louis E. Strothman, *Chairman;* Fred H. Dorner, *Secretary;* M. A. Beck, Walter C. Lindemann, R. H. Robinson, Arthur Simon, Henry Weickel

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Wm. H. Kavanaugh, *Chairman;* E. J. Heinen, *Vice-Chairman;* F. W. Rose, *Secretary-Treasurer*

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C. R. Weymouth, *Chairman;* Frank H. Varney, *Vice-Chairman;* C. T. Hutchinson, *Secretary;* H. L. Terwilliger, J. T. Whittlesey

**St. Louis**

F. E. Bausch, *Chairman;* E. L. Ohle, *Secretary;* H. Wade Hibbard, John Hunter, L. C. Nordmeyer

## LOCAL MEETINGS OF THE SOCIETY

**Boston**

H. N. Dawes, *Chairman;* W. G. Snow, *Secretary;* C. H. Fish, A. L. Williston, C. W. E. Clarke

**New Haven**

H. B. Sargent, *Chairman;* E. H. Lockwood, *Secretary;* F. L. Bigelow, L. P. Breckenridge, J. A. Norcross

**New York**

Edward Van Winkle, *Chairman;* John P. Neff, *Secretary;* H. R. Cobleigh, *Treasurer;* J. J. Swan, Edwin J. Prindle

**Philadelphia**

H. E. Ehlers, *Chairman;* W. R. Jones, *Secretary;* Robt. H. Fernald, Hugo Bilgram, Geo. R. Henderson, D. R. Yarnall

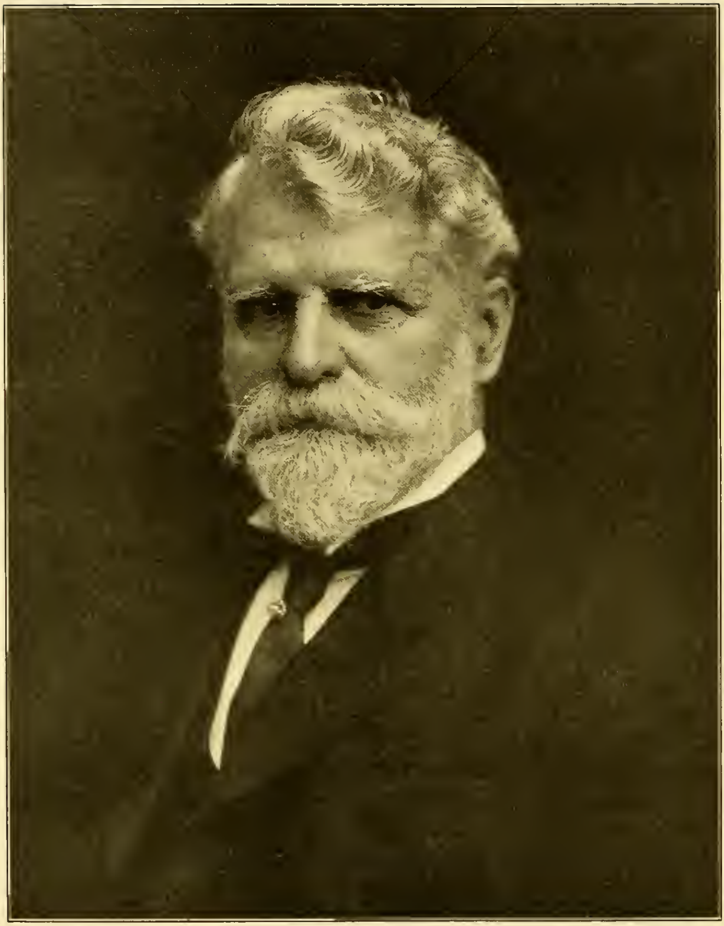
## OFFICERS OF AFFILIATED SOCIETY

**Providence Association of Mechanical Engineers**

W. H. Paine, *President;* Arthur H. Annan, *Vice-President;* J. A. Brooks, *Secretary;* A. H. Whatley, *Treasurer*

# OFFICERS OF THE STUDENT BRANCHES

| INSTITUTION | DATE AUTHORIZED BY COUNCIL | HONORARY CHAIRMAN | CHAIRMAN | CORRESPONDING SECRETARY |
|---|---|---|---|---|
| Armour Inst. of Tech. | Mar 9, 1909 | G. F. Gebhardt | F. L. Brewer, Jr. | J. A. Agee<br>Downers Grove, Ill. |
| Carnegie Inst. of Tech. | Oct 14, 1913 | W. Trinks | J. B. Patterson | Julius Guter<br>303 Dithridge St., Pittsburgh, Pa. |
| Case School of Applied Science | Feb 14, 1913 | F. H. Vose | L. W. Hodons | Burton S. Dake<br>1886 E. 75th St., Cleveland, O. |
| Columbia Univ. | Nov 9, 1909 | Chas. E. Lucke | H. F. Allen | A. S. Henry<br>333 Central Park W., New York, N. Y. |
| Cornell Univ. | Dec 4, 1908 | R. C. Carpenter | J. G. Miller | W. W. Robertson, Jr.<br>6 South Ave., Ithaca, N. Y. |
| Kansas State Agri. College | Feb 13, 1914 | A. A. Potter | J. E. Bengston | L. A. Wilsey<br>P. O. Box 564, Manhattan, Kan. |
| Lehigh Univ. | June 2, 1911 | P. B. de Schweinitz | A. V. Bodine | H. A. Brown<br>Lehigh Univ., South Bethlehem, Pa. |
| Leland Stanford Jr. Univ. | Mar 9, 1909 | W. F. Durand | J. A. Gibb | C. L. Addleman<br>219 Ramona St., Palo Alto, Cal. |
| Mass. Inst. of Tech. | Nov 9, 1909 | E. F. Miller | F. G. Purinton | H. E. Morse<br>Box 233, East Bridgewater, Mass. |
| New York Univ. | Nov 9, 1909 | C. E. Houghton | | |
| Ohio State Univ. | Jan 10, 1911 | Wm. T. Magruder | R. D. Rogers | P. W. Sheatsley<br>1778 E. Main St., Columbus, O. |
| Penn. State College | Nov 9, 1909 | J. P. Jackson | C. F. Kennedy | D. E. Hewitt<br>Box 276, State College, Pa. |
| Poly. Inst. of Brooklyn | Mar 9, 1909 | W. D. Ennis | M. Van Valkenburgh | Samuel Kobre<br>Poly. Inst. of Brooklyn, Brooklyn, N. Y. |
| Purdue Univ. | Mar 9, 1909 | G. A. Young | S. A. Peck | T. S. Tulien<br>c/o Purdue Univ., Lafayette, Ind. |
| Rensselaer Poly. Inst. | Dec 9, 1910 | A. M. Greene, Jr. | C. P. Brown | W. Kelly<br>374 Clinton Ave., Albany, N. Y. |
| State Agri. College (Colo.) | Oct 9, 1914 | J. W. Lawrence | A. T. Johnson | T. H. Sackett<br>State Agri. College, Fort Collins, Colo. |
| State Univ. of Iowa | Apr 11, 1913 | R. S. Wilbur | L. A. White | H. C. Doane<br>Newton, Ia. |
| State Univ. of Kentucky | Jan 10, 1911 | F. P. Anderson | M. Brooke | T. R. Nunan<br>345 S. Limestone St., Lexington, Ky. |
| Stevens Inst. of Tech. | Dec 4, 1908 | Alex. C. Humphreys | G. F. Blixt, Jr. | Barton V. Hilliard<br>531 River St., Hoboken, N. J. |
| Syracuse Univ. | Dec 3, 1911 | W. E. Ninde | W. C. Dexter | G. E. Furbush<br>718 Irving Ave., Syracuse, N. Y. |
| Throop College of Tech. | Nov 13, 1914 | W. H. Adams | R. O. Catland | H. A. Black<br>32 N. Grand Oaks Ave., Pasadena, Cal. |
| Univ. of Arkansas | Apr 12, 1910 | B. N. Wilson | M. McGill | C. Bethel<br>Univ. of Ark., Fayetteville, Ark. |
| Univ. of California | Feb 13, 1912 | Joseph N. LeConte | A. C. Moorhead | H. L. McLean<br>Univ. of Cal., Berkeley, Cal. |
| Univ. of Cincinnati | Nov 9, 1909 | J. T. Faig | J. W. Dollman | A. J. Langhammer<br>713 Crescent Ave., Covington, Ky. |
| Univ. of Colorado | Apr 10, 1914 | P. S. Rattle | L. J. Brady | S. S. Cooke<br>1089 13th St., Boulder, Colo. |
| Univ. of Illinois | Nov 9, 1909 | W. F. M. Goss | H. E. Austin | E. Gehrig<br>Univ. of Illinois, Urbana, Ill. |
| Univ. of Kansas | Mar 9, 1909 | P. F. Walker | O. T. Potter | I. W. Clark<br>1212 Louisiana St., Lawrence, Kan. |
| Univ. of Maine | Feb 8, 1910 | Arthur C. Jewett | W. L. Wark | H. A. Titcomb<br>Phi Kappa Sigma House, Orono, Me. |
| Univ. of Michigan | Apr 10, 1914 | John R. Allen | R. H. Mills | C. H. McClellan<br>928 Oakland Ave., Ann Arbor, Mich. |
| Univ. of Minnesota | May 12, 1913 | W. H. Kavanaugh | J. A. Colvin | J. L. Hartney<br>1410 Fifth St., S. E., Minneapolis, Minn. |
| Univ. of Missouri | Dec 7, 1909 | H. Wade Hibbard | L. L. Leach | P. R. A. Nolting<br>615 Turner Ave., Columbia, Mo. |
| Univ. of Nebraska | Dec 7, 1909 | J. D. Hoffman | D. W. Watkins | L. L. Westling<br>Station A, Lincoln, Neb. |
| Univ. of Wisconsin | Nov 9, 1909 | H. J. Thorkelson | M. A. Cook | |
| Washington Univ. | Mar 10, 1911 | E. L. Ohle | R. V. Henkel | E. C. Schisler<br>Washington Univ., St. Louis, Mo. |
| Worcester Poly. Inst. | June 16, 1914 | Ira N. Hollis | W. H. Crippen | H. P. Fairfield<br>Worcester Poly. Inst., Worcester, Mass. |
| Yale Univ. | Oct 11, 1910 | L. P. Breckenridge | R. F. Frost | W. S. Snead<br>96 Wall St., New Haven, Conn. |



AMBROSE SWASEY, PAST-PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, DONOR OF THE INITIAL GIFT TO THE ENGINEERING FOUNDATION, INAUGURATED BY THE UNITED ENGINEERING SOCIETY FOR THE FURTHERANCE OF RESEARCH IN SCIENCE AND ENGINEERING, OR FOR THE ADVANCEMENT IN ANY OTHER MANNER OF THE PROFESSION OF ENGINEERING AND THE GOOD OF MANKIND.

# THE HISTORY OF THE SOCIETY

IN 1914 the Society completed one-third of a century of its organic life. The Council requested the Honorary Secretary who had served as Secretary during twenty-three years of that period to prepare a record of what the Society had accomplished in that time.

This history is about ready to go to press. It will contain over 200 pages in the standard form of the Transactions of the Society and will be illustrated by over 50 photogravures, portraits of the Presidents and illustrations of the buildings and headquarters which the Society has occupied. It seeks to give the personal touch which the mere summation of the minutes of the Society cannot supply. Its chapters include, among other subjects:

- The Preliminary Steps of Organization
- Some Principles of Society Philosophy
- Some Early Members of the Society
- Some Notable Papers Read Before the Society
- Meetings of the Society and What Has Made Them Memorable
- Internal or Office Activities of the Society
- The Headquarters
- The European Trips
- Professional Standards
- Professional Sections, Groups and Student Branches

The history will be sold on a subscription basis at $5.00 per volume in standard binding. Those desiring copies of the history will please communicate with the Secretary of the Society. Members may place their orders and have the volume charged to their accounts.

THE JOURNAL OF

# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 FEBRUARY 1915 Number 2

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## COMING MEETINGS OF THE SOCIETY

*February* 9, *New York City*. Paper: A Proposed System of Classifying and Digesting the Society's Records to Render Instantly Available All Information on Each Particular Detail of Every Subject Treated, by Edwin J. Prindle.

*February* 10, *Milwaukee, Wis.* Inspection of the new Milwaukee intake tunnel. Chicago members also invited.

*February* 11, *Buffalo, N. Y.* Subject: Use of Cast Iron in Reinforced Concrete, by A. G. Hillberg.

*February* 15, *Boston, Mass.* Boston City Club. Annual Joint Engineers' Dinner.

*February* 25, *Buffalo, N. Y.* Address by M. W. Alexander on a subject to be announced.

*February* 26, *Boston, Mass.* Subject: Industrial Education, by Walter C. Fish, Manager Lynn Works, General Electric Company.

*February* 26, *Chicago, Ill.* Subject: Refrigeration; Ice-Making as a By-Product of Central Stations.

THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 February 1915 Number 2

## THE ENGINEERING FOUNDATION

On Wednesday evening, January 27, 1915, was held in the auditorium of the Engineering Societies Building the inaugural exercises of The Engineering Foundation, established by the United Engineering Society. The initial gift to the Foundation of $200,000, made by Ambrose Swasey, Past-President of The American Society of Mechanical Engineers, was formally accepted at this time. So far as known this is the first instance of a foundation devoted to engineering purposes. This meeting constituted also an appropriate tribute to the generous gift made to the Foundation and gave opportunity for expression of the satisfaction and approval which are felt by engineers everywhere at the establishment of a means of promoting the good of mankind through the work of the engineer along the broadest lines.

Gano Dunn, President of the United Engineering Society and Past-President of the American Institute of Electrical Engineers, acted as presiding officer, and on the platform were seated representatives of the three societies constituting the United Engineering Society, and of the American Society of Civil Engineers. Members of the four societies and many other friends interested in the profession composed the audience.

The first address of the evening was made by Gano Dunn, who reviewed the history of the Engineering Societies Building, the purpose of the United Engineering Society, and the formation of The Engineering Foundation.

### ADDRESS BY GANO DUNN

Mr. Dunn said that the United Engineering Society is a creation for the purpose of enabling three of the great engineering societies, The American Society of Mechanical Engineers, the American Institute of Mining Engineers and the American Institute of Electrical Engineers, to do jointly more than they could do separately. It is a corporation which holds in trust the property on which the Engineering Societies Building is located, the building itself, and its contents. The property and its contents were contributed by the founder societies, and the building by Mr. Andrew Carnegie. The interesting fact was pointed out that the celebration of the inauguration of The Engineering Foundation occurs almost exactly ten years from the date of the first meeting of the United Engineering Society, so that this occasion is partly a decennial. It is to be hoped that in the next ten years as much fruit will be born of the Foundation as the United Engineering Society has produced during the past ten years. The charter of the United Engineering Society contained among the other paragraphs describing its powers the following: "To take real and personal property by grant, devise or bequest, and use, maintain, occupy, lease, mortgage and convey the same." It was in the minds of the men who drafted this document that the time would come when the usefulness of the United Engineering Society would extend far beyond a corporation for owning and administering the building. But, said the speaker, ten years went by before that provision was made use of, and tonight we are together because a distinguished engineer, a man of marked intellectual power, a man of marked personality, has felt in his heart that he wanted to do what would most benefit not only the engineering profession but mankind, and believed that through the agency of the United Engineering Society it could be done.

We have foundations of many kinds,—for philanthropy, for civic betterment; foundations for many noble purposes seem to characterize American public life. But as yet we have to hear of a foundation in engineering. At last our turn has come, at last the human element is recognized among engineers in benefaction, and at last engineering is included among those human activities which are felt to be sufficiently important to promote.

The speaker explained that when the trustees of the United Engineering Society came to consider all the possible objects and uses to which a foundation could be put, they felt it could be best administered if in the hands of a responsible and distinguished board, separate from their own, with entire freedom

as to the expenditure of their resources. It was felt further that the work could never be successful or representative of the whole field of engineering if its roots were in only the three national engineering societies which constitute the United Engineering Society. Without the coöperation of the American Society of Civil Engineers, he said, "the pioneer society that we and all engineers have looked up to with honor and respect; the society from which we have taken our standards of conduct, the society whose numbers are more advanced generally in years, the society whose name we as engineers have loved to conjure with when we have been speaking with pride of the accomplishments of engineers—that society, we felt, must take part in the work of the United Engineering Society, or the work of the Foundation could not be expected to be successful. The structure of the Engineering Foundation, therefore, was so arranged that it should be managed by a Board of eleven members, of which the President of the United Engineering Society should be ex-officio one, two members from each of the founder societies, two from the American Society of Civil Engineers, and two from the world at large. In this latter provision the trustees hoped to introduce into the Foundation an outside element and a point of view that would forever save the Board from becoming narrow, and would likewise inspire new ideas." The speaker said that in his opinion they never did so wisely as when they called upon the world in general to share with them in administering this great trust.

Mr. Dunn said that in proposing this structure to our sister society and inviting them to share in the management of the trust, a letter of acceptance was received which the trustees felt insured that the future of The Engineering Foundation would be a brilliant one. After consideration on the part of its officers and its official board of direction, the American Society of Civil Engineers replied as follows:

I have the honor to state that your letter of January 5, 1915, was presented to the Board of Direction of this Society, together with the Amendments to the Charter and By-Laws of the United Engineering Society, which provide for The Engineering Foundation, and that the action of the undersigned in the matter up to that date was approved.

I am instructed further to say that the American Society of Civil Engineers is very glad to become one of the four societies to be represented on the Board in whose hands the administration of The Engineering Foundation is to be placed.

I am instructed also to express to you, and through you to all who have been interested in this matter, and especially to the donor of the present endowment, the appreciation of the Board of Direction of the American Society of Civil Engineers of the courtesy which has been extended to the Society in giving it the opportunity to participate in this movement.

Yours very truly,
(*Signed*) Chas. Warren Hunt, *Secretary*.

In conclusion Mr. Dunn said:

"This structure was created at this time because of the urging of the donor, whose name I have not mentioned, but whose personality I have indicated, and now that I have described it, I should like to announce what he has done, and who he is. In doing this, I again wish to comply with his request that his part be made as small as possible, and I must say that this on my part, is a perfunctory compliance, because, while he undoubtedly wishes it so, we can never forget how large is the part he has played not only in giving this endowment, but in initiating and creating the structure that undoubtedly will be the receptacle of many future endowments, and the center and source of much important work in the future."

This is the letter:

Dear Professor Hutton: I am pleased to acknowledge receipt of yours of the 20th instant, also copy of the minutes of the Board of Trustees of November 19, and I appreciate the courtesy of the Board in submitting them to me before final approval.

The name adopted, "The Engineering Foundation," is ideal, and the plan of organization and administration, as given in the minutes, is along the broadest lines and most admirable in every respect. I have no suggestions or recommendations to offer.

As soon as I am advised that the plan of organization of The Engineering Foundation submitted has become the law of The United Engineering Society, I will be pleased to transmit to the officer designated by the Society, the two hundred thousand dollars ($200,000) which constitutes my gift to the Society for The Engineering Foundation; the income only of which is to be used for the purposes of the Foundation.

As to the date of the general meeting when the plan of the Foundation is to be made public, if agreeable to the Board, it seems to me it would be well to have it some time during the last week in January.

I want the members of the Board to know how much I appreciate the interest they have manifested in working out the problems relative to the Foundation, and the pleasure it has given me to be associated with them in their splendid undertaking.

With all best wishes,

Very truly yours,
(*Signed*) Ambrose Swasey.

#### REMARKS BY AMBROSE SWASEY

Mr. Swasey was then called upon by the Chairman and very briefly expressed his appreciation of the cordial manner in which the announcement had been received. He believed that the meeting was also evidence of the appreciation felt of what had been accomplished by the United Engineering Society and the work which they had done in planning and bringing about this Foundation. It is a very simple matter to throw a few shovelsful of coal under the boiler, he said. We must have fuel if we would have power. But to the engineers who designed the boiler and the engine, and who so proportioned them and so correlated them that the products of combustion can be used to greater advantage than ever before for the benefit of mankind, the greater credit belongs.

#### ADDRESS BY ROBERT W. HUNT

Robert W. Hunt, Past-President of the American Institute of Mining Engineers, paid a personal tribute to Mr. Swasey, as a lifelong friend, and said that it is

one of the few certainties of this world that the greatest earthly happiness comes to those who have made others happy. The United Engineering Society, which will administer this Foundation "to develop, direct and conserve the forces of nature for the benefit and uplift of mankind through the instrumentality of the engineer," was made possible by the generosity of one man, Andrew Carnegie. He wisely surrounded his gift made in recognition of the profession and the men who had made possible his own financial success, with conditions which required efforts and contributions from others, and also, as became a true humanitarian, did not make the institution a personal one. As a result engineers in every department of the profession, as well as all believers in engineering, have united in making the proposition successful, entirely ignoring self.

This Foundation is the conception of one man who does not seek individual aggrandizement, but rather through his own munificence to create a base upon which others can unite with him in building a structure which will benefit all humanity. This structure will not be his nor any other man's, but to each one who may hereafter add to its growth and usefulness will be given the happiness incident to helping to uplift mankind. This is no new rôle to Mr. Swasey, to whom all human beings, whether they have the yellow skin of the Far East or are the laboring boys and men of his own country, are fellow-mortals. While he built telescopes to comprehend in part the incomprehensible universe, his love for and his desire to serve his fellow men has grown and has manifested itself in many ways.

Mr. Hunt related an incident of Mr. Swasey's successful fight for the new post office building in Cleveland, which was finally built, as a result of his efforts, of granite instead of limestone. This was but an instance of Mr. Swasey's many unselfish efforts for public welfare. Many of his works of benefaction were known only to a few. He spoke also of his lifelong friendship with Mr. Swasey and said that in the starting of this project Mr. Swasey was only opening the way and making it practical for others to give.

#### ADDRESS BY HENRY S. PRITCHETT

Dr. Henry S. Pritchett, President of the Carnegie Foundation for the Advancement of Teaching, spoke upon the significance of the gift and its meaning for engineering science and civilization. Great numbers of research institutes already exist in Europe and America, but never has such an agency for research been placed in the hands of a group of engineering societies. The word research has become almost a shibboleth in university circles; but it must be confessed that a great proportion of this is the imitation, not the reality. In the sense in which it is used in this Foundation, he thought, it means the attempt to formulate and solve those problems of science which touch most directly the comfort, the happiness and the progress of the nation and of the world. In this process it requires quite as high an order of ability to formulate the problem clearly as to solve it.

"Research considered as a process of scientific thinking and discovery is not a task to be set before the immature and the untrained. It is quite true that the best training for research may not always lie in university halls. A long roll of illustrious men whose names the world cherishes found their way to the solution of the great problems of science and of industry by other paths than the university. This means simply that they became thinkers in their own way.

"The process of research, therefore, as one may expect it to be carried forward by such an agency as this, involves first the clear formulation of problems, and then the attack upon the problem by all the avenues and by all the agencies of science; and this process, it may well be assumed, will be successfully carried out only by those men who have learned to think, who are familiar already with the present state of science, and who—using this as a basis—push forward the boundaries of our knowledge into new fields. True research implies clear thinking, minute knowledge of the field of science, and patient endeavor.

"The development of such a research agency by the great engineering societies, through a fund entrusted to them, has, to my thinking, far reaching significance, first, for engineers themselves; secondly, for research; and in the third place, for the public, the great body of citizens.

"So far as engineers themselves are concerned, the offer and acceptance of this foundation signalizes the fact that engineering in America is to-day a profession, not a business. For two centuries and more the civilized nations have recognized three great professions—that of the law, of medicine and of the clergy. Only within our generation has engineering been admitted to the fellowship of this group; and it has come because the world now recognizes that the man who serves in the field of applied science, if he serve in the right spirit, gives a part of his energy to the service of the public. It is in just this respect that business differs from a profession. Physician and lawyer and clergyman accept pay, but in each of these professions it is clearly recognized that the service must not be governed by the pay, that a large part of the energy of the profession must be given to the service of the common good, that members of a profession occupy a quasi-public relation. Only when the men of a calling attain this sense of professional consciousness can the calling pass from that of a business to that of a profession. The members of a vocation who take upon themselves the responsibility for the direction and encouragement of scientific research have risen out of the business of engineering into the profession of engineering.

"With regard to research it may be said that, while engineering research in its essence partakes of the nature of all research, it undertakes to formulate an answer to certain questions which are not likely to be dealt with successfully elsewhere. Ever since universities and institutes for research have existed there has gone on the discussion between what is called theory and what is called practice. As Professor

Pupin has well put it, 'It is the practice which formulates the question; theory seeks to answer it.'

"It is the man in the practice who formulates the question. It is the scientist who finds the answer.

"The criticism of university research has been that theory and practice, the man who formulates and the man who solves, have not always been happily related. In a research agency conducted by associations of engineers there ought to be the most fortunate alliance of theory and practice. Here, the practitioner who questions and the man who seeks to solve, the man who formulates and the man who delves ought to find their closest association. And it will be interesting to observe how, under such auspices, theory and practice will learn to go hand in hand.

"To the public the foundation of such a research agency in the field of applied science may well mean the inauguration of a series of studies having the greatest significance for public well-being and for public needs. The most striking illustration of such a result has been already given in the history of a small research laboratory of applied science, started in the technical school, at Charlottenburg, some forty years ago. The effort arose out of the questions formulated and laid before the scientific staff of the technical school by the men of the steel industry; and out of the solutions of these questions the steel industry of Germany grew. Gradually the inquiry arose, why should there not be an institute of engineering research to which any citizen engaged in the industries may bring his problems? to whose laboratories may be brought not alone the questions relating to the manufacture of steel, but those relating to the chemical industry, textile industry, electrical manufacturing and industries of every sort, in a word, all the questions which to-day in the manufacturing establishments of a great nation are constantly being asked?

"Out of the little research laboratory at Charlottenburg have grown the great testing laboratories (Versuchtanstalt covering many acres and offering themselves freely to the solution of every technical question that the industries in Germany can present. Any company engaged in the industries may bring its problems here. Any experts may come in and take part in the study, all the literature on the subject is made available, and under the combined efforts of the expert of the government laboratory and the experts of the industry a solution is generally found.

"The process is illustrated by the story which a paper manufacturer in Berlin told to me some years ago. His company manufactured wood pulp from the forest of a certain region. A change was made and their wood supply was drawn from another region. The formulae they had hitherto used no longer sufficed, and despite every effort of their own no solution had been found. Financial ruin stared the company in the face. The problem was carried up to the government laboratories of engineering research. At the end of two months all difficulties had vanished and prosperity returned to the manufacturer.

"Dr. Martens, the director of the research institute at Grosslichterfelde, told me that the complete and orderly collection of scientific literature and of scattered scientific solutions in research made available at Grosslichterfelde was one of the great factors in the success of the research establishment. 'Four times out of five,' said he, 'when a manufacturer brings us a problem we find that it has already been solved somewhere in the world by somebody, but by someone who generally used the solution in a different connection. Our greatest service is to place at the disposal of the inquirer the entire literature of his subject, and in this he will generally find a solution of his question already made.'

"Who can tell but that this modest agency for research, under the direction of the great engineering societies of America, may develop in due course into a national establishment to which any man in the industries may bring his problem with full hope of solution?

"We found here to-night an agency for human uplift and human development. It is founded not in brick and mortar but in the living engineers of these great engineering societies, which shall go on from decade to decade and from generation to generation. If our civilization endures, this association of engineers will develop with the ages. They will never die. And in their hands this agency of research will also be immortal, serving humanity from century to century and from age to age.

"It has been founded by an engineer at once wise and modest. To have founded such an immortal agency for human endeavor is to become oneself a partaker in immortality."

### REMARKS BY CHARLES MC DONALD

Following the address by Mr. Hunt, the Chairman called upon Mr. Charles McDonald, Past-President of the American Society of Civil Engineers, saying that if The Engineering Foundation had no other virtue than to bring into closer unity the four great engineering societies, it would have accomplished results of greatest value.

In response Mr. McDonald said that the American Society of Civil Engineers welcomed the efforts to be made through this gracious gift to The Engineering Foundation. His society would be glad to coöperate in working for the general good of the profession. No matter what organization he was representing, he wished to be considered at this time as a member broadly of the whole profession.

### REMARKS BY ALEX. C. HUMPHREYS

Dr. Alex. C. Humphreys, Past-President of The American Society of Mechanical Engineers, then formally accepted Mr. Swasey's gift in behalf of the Board of Trustees of the United Engineering Society. He quoted the by-law of the Society which covered the administration of such a fund and which reads as follows:

The Engineering Foundation Board shall have discretionary power under the By-Laws in the disposition of the funds received by it.

The Board may use any part of its funds and in any manner, which it deems proper for the furtherance of research in Science and Engineering, or for the advancement *in any other manner* of the Profession of Engineering and *for the good of Mankind.*

The Board may, by publication or public lectures or *by other means*, in its discretion, make known to the world the results of its undertakings.

This By-Law, he said, had been written in an effort to interpret Mr. Swasey's broad-minded and self-effacing intentions.

The acceptance of the fund, he said, meant the acceptance of a grave responsibility, which would, he believed, be met with the full determination on the part of the representatives, present and future, of the four societies to administer this fund and additional contributions in the interest of the larger needs of mankind. He hoped that the Foundation in its activities would always stand for the truth, the whole truth and nothing but the truth.

## AMBROSE SWASEY

### Donor of the Initial Gift to the Engineering Foundation

Ambrose Swasey is widely known as a member of the firm of Warner & Swasey of Cleveland, Ohio, prominent machine tool builders and the foremost builders of telescopes in the world. Among the instruments which they have designed are the famous Lick, Yerkes, and United States Naval Observatory telescopes, as well as the great 72-inch reflecting telescope for the Canadian Government, which is now under construction. Mr. Swasey is known also, in addition to his engineering achievements, for his practical efforts towards scientific education and the advancement of the profession. His gift for the establishment of The Engineering Foundation is in line with these undertakings, which may be destined to outlast his fame as an engineer. Mr. Swasey gave the handsome observatory to Denison University at Granville, Ohio, and the science building for the University of Nanking and the Young Men's Christian Association Building for the Canton Christian College now being erected in China, were made possible through his gifts. He has also, as president of the Warner & Swasey Company, interested himself earnestly in the establishment and conduct of its school of apprentices, and indeed the weight of his influence is to be found in every project tending to the development and encouragement of the human element, helping men to help themselves.

Dr. John A. Brashear, a life-long friend of Mr. Swasey, gave the following account of Mr. Swasey's life in an article which appeared in Cassier's Magazine for March 1897. The whole article, which cannot here be reproduced because of lack of space, is well worth reading as the tribute of one eminent astronomer to another.

"Ambrose Swasey was born in Exeter, N. H., his ancestors being among the early settlers of New England, coming to America in 1638. He received his education in the 'Little Red School House' of the district, and his after life has shown that the seed sown by the old schoolmaster fell upon good ground. At the age of eighteen he entered upon the machinist's trade in Exeter, and in 1870, in company with his present partner, Mr. Worcester R. Warner, he left the granite hills of his native State to go into the employ of the Pratt & Whitney Company, at Hartford, Conn. His energy and ability soon became manifest to his new employers, and his aptness in the solution of mechanical problems was so thoroughly appreciated, that the remark, 'Send it up to Swasey,' was a common one with them.

"While in charge of the gearing department, he invented and perfected the epicycloidal milling machine for producing the true theoretical curves of the teeth of gears, and a few years later he made another advance step in the solution of that difficult problem, inventing an entirely new proeess for generating and cutting spur gears, which proved a practical solution of the very important theory of the interchange system of gearing. In 1880, Mr. Swasey resigned his position with the Pratt & Whitney Company and, together with his present partner, established in Cleveland, O., the business which has since grown to such large proportions. Mr. Swasey's inventive and mechanical genius has emphatically manifested itself in the design and construction of the fine machine tools and astronomical instruments made by his firm.

"It seems a most fortunate circumstance that these two men, Ambrose Swasey and Worcester R. Warner, should have associated themselves together as partners, for although the making of astronomical instruments was not in their original scheme when starting the business of machine construction, Mr. Warner's taste for astronomy, and his interest in the appliances used by astronomers, combined with Mr. Swasey's love for artistic design, and his ability as a mechanical engineer, naturally led them to take hold of the questions pertaining to such instruments.

"In recent years observatories and instruments had increased to such dimensions in America that most intricate problems, requiring the highest engineering skill, were demanding solution. The largest refracting telescopes constructed previous to 1880 were the 26-inch telescope of the United States Naval Observatory, at Washington, D. C., the 27-inch of the University of Vienna, Austria, and the 30-inch instrument of the Pulkova Observatory, Russia; but the Lick telescope, as projected, was to have nearly half as much more light-gathering power than any refractor that had hitherto been constructed, and the difficulties of mounting such an immense instrument are enormously greater than those attending the construction of a smaller one.

"In 1886 the Lick trustees invited four firms to submit designs for the 36-inch telescope, which was to be the largest and most powerful ever constructed. Two of the competing firms were from abroad and two from the United States. . . .

"The competing designs for this great telescope were sent to the Lick trustees in San Francisco, and after careful consideration the plans submitted by Messrs. Warner & Swasey were accepted, and they were awarded the contract, although their price was the highest. The design of this important instrument was carefully studied in every detail, and the highest standard of excellence was maintained throughout. It was finally erected on Mount Hamilton, in California, during the winter of 1887 and 1888 under Mr. Swasey's personal supervision."

This instrument was very naturally subjected to much criticism, but it stood all the tests and when the Government desired to reconstruct the Naval Observatory at Washington in 1890, the Warner & Swasey Company were given the contract for the 26-inch telescope; and they were also later entrusted with the task of making the 40-inch telescope, and also the 90-foot dome and the 75-foot elevating floor, for the Yerkes Observatory, Williams Bay, Wis.

The manufacture of meridian circles, transits and other astronomical instruments of extreme accuracy and precision has formed a large part of the firm's work, and in the designing of all these instruments Mr. Swasey has taken an important part. For graduating the fine circles of these delicate instruments, it was necessary to have a circular dividing engine, and as there was no instrument in the country of sufficient accuracy, the problem was taken up of designing and perfecting such an engine which, when completed, was capable of dividing circles automatically up to 40 inches in diameter with an error of less than one second of an arc, probably the most accurate circular dividing engine ever constructed.

Mr. Swasey is the inventor of a number of instruments used by the Government in its coast defense, including several improvements in the construction of range finders.

Many honors have come to Mr. Swasey for his work and achievements. He is a past-president of the Society, a member of the Institution of Mechanical Engineers of Great Britain and of the British Astronomical Society, he is a Fellow of the Royal Astronomical Society, is past-president of the Cleveland Engineering Society, and, in 1900, received from the French Government the decoration of The Legion of Honor for his achievements in the design and construction of astronomical instruments. He was a member of the Jury of Awards of the Nashville, the Pan-American and the St. Louis Expositions and Vice-President of the Jury of Awards of the Jamestown Exposition. In 1905 he served as president of the Cleveland Chamber of Commerce, and the same year the degree of Doctor of Engineering was conferred upon him by Case School of Applied Science. Mr. Swasey was married October 24, 1871, to Lavina D., daughter of David and Sarah Ann (Dearborn) Marston, and he and Mrs. Swasey had traveled extensively up to the time of Mrs. Swasey's death early in the year of 1913.

## TESTIMONIAL DINNER TO AMBROSE SWASEY

The President and Trustees of the United Engineering Society tendered a testimonial dinner to Mr. Ambrose Swasey, Past-President of The American Society of Mechanical Engineers, at the University Club, Tuesday evening, January 26, 1915.

There were present the members elect of the Board of Trustees of the United Engineering Society, the presidents and secretaries of the four national engineering societies and the Engineers' Club, the speakers at the inauguration of the Foundation on Wednesday, a group of other friends in the several societies who had been conferring with Mr. Swasey in the development of the Foundation, and the benefactors of the founder societies.

Impromptu addresses were made by John Hays Hammond, E. D. Adams, Charles F. Scott, and T. A. Rickard of London, member of the Iron and Steel Institute, editor of the Mining Review of London and the Mining and Scientific Press of San Francisco. Mr. Rickard commented on the status of the progress of the professional engineer in relation to the status of members of the other professions, of law, etc. Dr. H. S. Pritchett also spoke of the enduring features of a foundation administered by an engineering society which would go on from generation to generation and from century to century. Dr. M. I. Pupin spoke of the opportunities of useful service which this Foundation could render. In conclusion, Mr. Swasey himself made a few remarks, saying that his contribution was only the beginning and that it was his hope that engineers generally would make further contributions. The final greeting to Mr. Swasey, all members of the dinner rising to their feet, was a vow similar to that made by the signers of the Declaration of Independence: "For the support of this Declaration. . . . we mutually pledge to each other, our lives, our fortunes and our sacred honor."

## COMMENTS ON THE ENGINEERING FOUNDATION

As the first endowment to be devoted to the advancement of engineering, much interest has been aroused as to the purposes for which The Engineering Foundation will be expended. Mr. Swasey in making the first gift to the Foundation, wisely and characteristically made no stipulation as to the method of its application, and there has as yet been no announcement from the Board which will administer the fund.

A number of members of the Society and others interested in engineering have been asked to express their opinion upon the value of this Foundation and to make any suggestions they may have as to how it may best

be applied. Quotations from their replies are given herewith. None of these embody any official statement, but will be interesting nevertheless as representing various viewpoints.

The replies follow:

My opinion of the significance of the Foundation is well expressed in a wire which I have formulated to send to Mr. Swasey on the morning of Wednesday, the twenty-seventh. It is as follows:

"My dear Mr. Swasey: This is a significant day. By your thoughtful and generous action, it introduces a process whereby new truth will be revealed, engineering practice will be improved, industry will be stimulated and the progress of mankind advanced. Pray accept from me, a humble worker in the ranks, expressions of sincere appreciation and renewed assurances of personal admiration and esteem. May God bless you and give you satisfaction and joy in the foundation you have created."—W. F. M. Goss.

The Engineering Foundation established by the United Engineering Society, to which Mr. Ambrose Swasey, Past-President of The American Society of Mechanical Engineers, is the first contributor, marks a new point of departure in the advance of the Engineering Profession.

Not the least important feature of this very important undertaking is the enlistment of the interest of the four national societies of Civil, Mining, Mechanical and Electrical Engineers in a common cause for the advancement of the Profession.

What Mr. Swasey has done others may be encouraged to do when it has been shown that The Engineering Foundation is being administered upon broad principles and the results obtained are of value and are given free to the Engineering Profession of the world. The success and the power for good of this great undertaking devolves upon The Engineering Foundation Board.—Jesse M. Smith.

I am delighted to know of the inauguration of The Engineering Foundation and I congratulate the profession not only on the possession of such an aid for the advancement of the arts and sciences connected with engineering but on having in its ranks one who is willing to aid in the work of benefiting mankind. I feel that such a foundation would have a wide field of usefulness in making grants to aid in investigations which are being made or which should be made. A little aid at the right time may help many to finish work which would remain unfinished without this. I am sure that great good will result from The Engineering Foundations.—Arthur M. Greene, Jr.

A natural use for the income of such a fund would be the carrying on of researches along mechanical lines through committees of the Society, in such a way as to add to the fund of engineering knowledge. As an illustration, such work as Mr. F. A. Halsey is proposing to do, when financial backing can be secured, in connection with the testing of worm drives and the action of worm wheel and spiral teeth, would seem to come directly in the class mentioned.

Also, such work as is being done by the various committees of the Society; for example, our Committee on Screw Thread Limits and Tolerances has suggestions in mind as to methods of gaging and measuring screws, so as to determine simultaneously the errors of lead and diameter. If funds were available to produce such gages and actually make a trial of them, more tangible results would follow than are possible at the present time.

It goes without saying that there would have to be careful guarding of the use of such funds as they would easily be dissipated in useless experiments and for side issues which would not materially advance the arts and sciences connected with engineering.—Luther D. Burlingame.

In my opinion the most important matter now required to advance the science of engineering, to place it on a high plane as a profession, and to facilitate the work of research in engineering, is the maintenance and publication at frequent intervals of a catalogue with abstracts of all engineering literature. This collection of abstracts should be similar to the abstracts made and published in the publication known as Chemical Abstracts; it should be so well indexed and furnished with cross references that a man interested in any one subject would quickly and accurately secure an abstract of all the articles that appear on that subject. It should be so complete that a patent attorney might use it for looking up the state of the art and rest assured that he would miss nothing within the period covered by the publication. It should be checked up at the end of every year with all the various indexes published, in order that it might be found that nothing had been missed. The abstracts should be made by technically trained persons and not by trained librarians.

They should be sufficiently comprehensive to give a man a very accurate idea of what the article contains, so that he can determine, for himself, whether or not it was worth his while to read the whole article, but should avoid all repetitions and unnecessary language. It should be so accurate as to remain the standard for this kind of work, and it should cover publications in the language of every country likely to interest engineers. It should be so practical that no engineer, who pretends to keep in touch with the progress of his profession, could afford to neglect to read it as promptly as it appeared.

In case such an index could be maintained it would be entirely unique among abstracts of this kind and would be a boon to the profession of engineering whose value it is impossible to over-estimate. The work should be done, however, in coöperation with other institutions that are making abstracts, in order that such collaboration might lessen the labor of all—Bradley Stoughton.

My judgment would be to utilize practically all of the income in paying the salary of a director, with enough off to provide for a stenographer and a minimum of other expense, such as printing.

There are a thousand different minor researches that might be carried on for the advancement of the arts and sciences connected with engineering and which perhaps would bring about some slight benefit to mankind, but I believe the biggest return that could be obtained for the amount at present available would be to put in charge of the Foundation a man of sufficient calibre to bring his good offices to bear on the coördination of such engineering research as is now being carried on and further to really find out about and keep in touch with what is now being done.

The standing of the Foundation in the community is going to be very largely determined by its early activities and it seems to me that the best impression on the community would be made by one strong man.—M. L. Cooke.

I cannot speak too highly of the generosity, public spirit, and devotion to the profession of that splendid man, Ambrose Swasey, through whose munificence the creation of The Engineering Foundation is due. As to the direction in which this fund could best be devoted to benefit the engineering profession and the human race, in my opinion the greatest need of the engineering profession today is neither more literature nor more scientific experiments to accumulate data, but a better appreciation by the public, which employs engineers, of what the engineer can do, coupled with a clearer understanding of the proper method to be adopted in engaging an engineer to undertake a particular piece of work.

Few engineers in active life who are in close touch with present day conditions, have the leisure to undertake a broad investigation of this sort and study out possible plans of action. An organization such as The Engineering Foundation, however, could employ and pay an engineer, and a competent staff, if necessary, to investigate this whole matter, and make it his business to find a solution as he would find the solution for an engineering problem.

It will, of course, be admitted that the ideal of placing an engineer perfectly equipped for his task in charge of every important piece of engineering work in the country is an ideal impossible of attainment. When one is aware, however, of the many million dollars which are spent in ill-advised and unwise work every year by cities and towns and private corporations, he cannot but feel that if the work were done by better engineers, far better results would be secured. Certainly no other subject compares with this in the interest it is now arousing in the engineering profession everywhere. All sorts of proposals are made and discussed by individual engineers and by engineering societies. An authoritative investigation, made by an organization representing all the national engineering societies, would be of value to every member of the engineering profession and could hardly fail to place the profession on a better footing before the public.—Charles Whiting Baker.

As a civil engineer by profession, I rejoice heartily in the good fortune which has thus come to the united engineering societies, and I feel that my best thought must be given to the request you raise irrespective of publicity. This latter, especially as it is exemplified by the press, does not interest me. I shall be glad, however, to give your association, as I am giving many others, the best counsel available to me, and give it as a silent partner.

I regret very much that I may not be with your company tonight, to indicate by my presence the high regard in which I have long held our friend Swasey, and the delight which his gift to the engineering profession brings to me.—Robert S. Woodward, *President, Carnegie Institute.*

I am very glad that someone has at last remembered the engineers and I believe a great deal of good can be done with the money already given.—Charles S. Howe, *President, Case School of Applied Science.*

The great question of the hour is a national technical efficiency. I do not mean a mere professional education, such as the efficient bookkeeper receives, but a general training, starting in boyhood and producing a high technical efficiency on the part of the individual that will prove a bulwark to him throughout life and forever relieve him from any anticipation of want through incompetence to earn a living.—Geo. F. Kunz.

Two great objects of the engineering societies are education and research. Both of these objects are worthy of the expenditure of vast sums of money and of unlimited amounts of energy. The Foundation now established will, I hope, increase in amount and magnitude in the future until the available sum is sufficient to undertake great achievements both in education and in research. The great need of the engineering profession is scientific research conducted with no regard to commercial results and without any influence from commercial organizations. Numerous fields invite study, consideration and investigation, and it is suggested that in the line of research alone the income of the foundation could be employed in such a way as to accomplish much to advance the engineering profession in its place of responsibility and contribute to the welfare and uplift of mankind.—R. C. Carpenter.

Only two things occur to me: first, I believe a scholarship would be a good thing, similar to the Whitworth scholarship in England, that is restricted to regular apprentices; second, a first class library bureau which would be free to the members of the various societies. Such a library bureau should not only give references to the members on subjects they require but should attempt to coördinate the vast amount of valuable information that is constantly appearing in our technical press. Any number of mistakes occur in engineering work, not because they have not been made before, but because there is no quick method for the men engaged in the work to obtain information.

For instance, I have been up against a problem of drawing cartridge cases and a comprehensive report on this art would be of the greatest value to me. I do not want references to a large number of periodicals; I would want the subject drawn off from the different sources of information in such a way that the information would be readily useful to me, with perhaps a reference to certain standard works on the subject, which would be found in any reasonably well organized technical library.—H. H. Vaughan.

It has always seemed to me unfortunate that there is in this country so little coöperation between those engaged in engineering and in the so-called pure sciences. The distinction should not be between those who do useful things and those who do things the practical applications of which are not obvious, but between those who discover new ways of doing things and those who follow the old ways. It might consequently be desirable for The Engineering Foundation to make plans that would secure coöperation between engineers and mathematicians, physicists, chemists, pathologists and other scientific men.

The British Association makes appropriations to committees which are to a certain extent responsible for work usually done by one or two members. If The Engineering Foundation should adopt this plan, it would be possible to appoint committees representing different aspects of engineering and science.—J. McK. Cattell, *Editor of Science.*

No subject of greater importance could demand the attention of The Engineering Foundation than that of an investigation of the subject of building a house for man. This house to have the following points: Extreme durability; no wood whatever, consequently incombustible; specially designed for fewest motions in connection with housekeeping; and specially designed for the elimination of unnecessary fatigue and sickness. Such houses can be built—no two alike—for less money than the individually designed houses of the present time, eliminating the tremendous loss to our country (due to fire), fire insurance, and fire protection. I have been working on this subject for several years in my spare time, and I know that it is a most needed philanthropy—that will at the same time make a good permanent return on the investment. (No great philanthropy will be permanent unless it pays.)—Frank B. Gilbreth.

## COUNCIL NOTES

At a meeting of the Council on January 8, 1915, Prof. Arthur M. Greene, Jr., was appointed to represent the Society on the Conference Committee of the engineering societies, to fill the vacancy caused by the death of Alfred Noble.

The following appointments on Standing Committees were announced by the President: Finance Committee, A. E. Forstall; Committee on Meetings, L. P. Alford, reappointed; Publication Committee, Henry Hess; Membership Committee, George A. Orrok; Library Committee, Jesse M. Smith; House Committee, O. P. Cummings; Research Committee, R. J. S. Pigott, A. M. Greene, Jr.; Public Relations, Spencer Miller; Constitution and By-Laws, James E. Sague. A new feature of appointments may be noted in that there is a member of the Council now on each of the Standing Committees, thus correlating the work of the Society and the Council.

A Committee on Local Sections, E. H. Whitlock, Chairman, W. F. M. Goss, L. C. Marburg, Walter Rautenstrauch and D. Robert Yarnall, was also appointed.

Appointments on local committees were approved as follows: Boston, C. W. Clark; Cincinnati, George Langen; San Francisco, C. R. Weymouth, chairman, F. H. Varney, vice-chairman, C. T. Hutchinson, secretary, J. T. Whittlesey, H. T. Terwilliger; Atlanta, Earl F. Scott, chairman, Park A. Dallis, secretary, Oscar Elsas, Frank H. Neely, L. W. Robert, Jr.; Minnesota, W. H. Kavanaugh, chairman, E. J. Heinen, vice-chairman, F. W. Rose, secretary.

The Council voted to accept the $1000 bequest of the late Rear-Admiral Melville, with the understanding that the income be allowed to accumulate until it is sufficient to defray the cost of a die for the medal. This medal is to be awarded annually to such competing member of the Society as shall present the best original paper or thesis on any mechanical subject presented to the Society.

Jesse M. Smith was nominated to the Trustees of the United Engineering Society for election to The Engineering Foundation Board.

The establishment of a student branch at Virginia Polytechnic Institute was approved, and L. S. Randolph appointed Honorary Chairman.

It was voted that a meeting of the Society be held in San Francisco in September 1915 previous to the International Engineering Congress.

An invitation was extended to H. G. Stott to act as chairman of a committee to coöperate with the Standardization Committee of the Manufacturers' Association in the recommendation of flange standards for hydraulic work.

CALVIN W. RICE, *Secretary.*

## PROGRESS ON THE REPORT OF THE BOILER COMMITTEE

Those interested in steam boilers and the steam boiler industry, will welcome news of the rapid progress toward completion of the present revision of the proposed Boiler Code. As a result of the chaotic conditions now existing in this industry, due to the widely varying legislative restrictions and requirements in different localities, the interest taken in this important division of the Society's activities has been almost universal. The important part which this subject played at the Annual Meeting in December, was referred to in last month's Journal (January, page 41); the discussion occupied six separate sessions, aggregating twenty hours in all of continuous meeting, in which the proposed Code and the work of the Committee were discussed in detail.

Since the Annual Meeting, the Boiler Code Committee has been in session almost constantly, studying the criticism and suggestions offered in the Annual Meeting discussion, and has made what is perhaps the most thorough and painstaking revision of the Code that has been undertaken since the inception of the work. The work of revision has continued without interruption except for Sundays and holidays, for six weeks, including both day sessions and night sessions until midnight. This comprehensive and complete revision indicates how stupendous an undertaking the preparation of this Code has been. The number of important points involved in a matter such as this, and the number of interests directly or indirectly affected have been almost overwhelming to a committee endeavoring to produce a Code that should at once be complete, rational, technically correct and yet free from any ruling that might prove derogatory to the interest of anyone concerned in this industry.

This remarkable undertaking was inaugurated nearly four years ago, the Committee having been appointed on September 15, 1911 "to formulate standard specifications for the construction of steam boilers and other pressure vessels and for the care of same in service." The original instructions by the Council to the Committee were to formulate a model engineers' and firemen's license law, a model boiler inspection law and a standard code of boiler rules. Due consideration was given to the necessity of constructing and installing steam vessels and their appurtenances in as nearly perfect a manner as possible, the importance of preventing carelessness in their operation and the wisdom of having them inspected at intervals by disinterested experts. The importance of the problem was emphasized by the fact that there occur in the United States every year on the average between 1300 and 1400 serious boiler accidents, of which 300 to 400 are violent explosions; these accidents kill between 400 and 500 persons, injure 700 to 800 more, and destroy more than a half a million dollars worth of property.

In the appointment of the Committee which was made during the presidency of Col. E. D. Meier, seven members were selected as follows: A consulting engineer, former member of the Massachusetts Board of Boiler Rules; two professors of engineering; two boiler manufacturers; and an insurance engineer. The Committee began work immediately, the members proposing such an arrangement of rules as their individual experience suggested. It was early decided to use as a basis for the new code, the rules that had for several years been in operation in the States of Massachusetts and Ohio and which were acknowledged to be the best set of rules then in existence. Numerous meetings of the Committee were held during which these rules were deliberated upon and then modified or added to in accordance with the best information obtainable and the Committee's best judgment.

A first preliminary draft of the rules for construction was then prepared, and was sent confidentially to professors of engineering in technical schools, superintendents of inspection departments of insurance

companies, chief inspectors in charge of United States, state and municipal boiler inspection departments, prominent engineers known to be interested in the construction and operation of steam boilers, prominent manufacturers of steam boilers, and editors of prominent engineering journals. A letter was sent with each copy requesting the recipient to read carefully the preliminary report and then to give the Committee the benefit of any criticisms or suggestions he had to offer. All replies were given careful consideration, and at the Spring Meeting of the Society held in St. Paul, on June 16th to 19th, 1914, it was decided to invite all interests affected to appear at public hearings to be held in the Engineering Society's Building in New York, beginning September 15th, 1914. These hearings were the means of bringing together representatives of the steel manufacturers, of the railways, of all classes of boiler manufacturers, also of the American Society for Testing Materials, of the Heating Ventilating Engineers, of the National Association of Stationary Engineers, and of other associations interested.

It is especially worthy of mention that at these hearings, an agreement was reached upon uniform specifications for boiler steel and other material; uniform specifications for boiler tubes; uniform rules for safety valves; uniform rules for fire tube boilers; uniform rules for water tube boilers; and uniform rules for steam and hot water heating boilers.

After the results of the September and October Hearings were thoroughly digested, the Code was entirely revised to incorporate such of the suggestions received as were applicable and another preliminary draft (the third printing) was brought out to facilitate further study of the subject by the Committee and other organizations with which it had been in conference at the Hearings. A very limited number of copies were printed, and distributed to the Committee members and the representative organizations only which had been in conference at the Hearings.

The result of the proofreading of this third printing was a number of modifications in the construction code and the decision to reprint the Code in the fourth printing with the proposed laws, the tables of joint efficiencies and the license application forms omitted. This edition, (the fourth printing) was called a Progress Report and was sent not only to the Committee members and representatives of the conferring organizations but also to every member of the Society, in time for examination and study prior to the Annual Meeting, December 1-4.

It was the result of this Progress Report, which was brought formally before the Annual Meeting for discussion that as reported in The Journal for January, the unusually extended discussion ensued, involving the six sessions from December 1-4, and at these meetings, a large amount of valuable constructive criticism was received on practically all details of the Code. The importance of this criticism, and the urgent interest of the boiler manufacturers who desire an immediate completion of the work, were the cause of a conference early in December, following the Annual Meeting, between members of the Boiler Code Committee and the boiler manufacturers' associations, at which it was decided that the purpose of the Code could best be served by, first, revising it immediately while the suggestions from the Annual Meeting were fresh in mind and, second, by submitting the details of the revision to representatives from all organizations and interests known to be affected by the introduction of the Code, as proposed. It was felt that the desired result could be more surely obtained by even closer coöperation than had been obtainable in the past, with such other organizations and interests, as they had been shown at the hearings and at the Annual Meeting, to have the detailed knowledge on the many important factors of the work which would be invaluable to the Committee in an advisory capacity.

The result was finally the appointment of an Advisory Committee of 18 members which should sit with the Committee in a final attempt to revise the Code into practical, workable form and thus permit of its presentation at the next meeting of the Society at Buffalo in June in such form that no serious criticism in any magnitude should be heard. This Advisory Committee which was selected to represent all the principal interests involved in the production of the Code includes the following members:

D. S. Jacobus, Advisory Engineer, Babcock & Wilcox Company, New York.
F. H. Clark, Gen. Supt. of Motive Power, Baltimore & Ohio R. R.
H. H. Vaughan, Assistant to Vice President, Canadian Pacific Ry., Montreal, Canada.
A. L. Humphrey, Vice President and General Manager, Westinghouse Air Brake Co., Wilmerding, Pa.
Karl Ferrari, Erie City Iron Works, Erie, Pa.
H. G. Stott, Supt. of Motive Power, Interborough Rapid Transit Co., New York.
I. E. Moultrop, Asst. Supt. Construction Bureau, Edison Elec. Ill. Co. of Boston.
W. F. MacGregor, Supt. of Experimental Dept., J. I. Case Threshing Machine Co., Racine, Wis.
Richard D. Reed, H. B. Smith & Co., Westfield, Mass.
M. F. Moore, Assistant to President, Kewanee Boiler Co., Kewanee, Ill.
S. F. Jeter, Supervising Inspector, Hartford Steam Boiler Inspection & Insurance Co.
Thos. E. Durban, Gen. Mgr., Erie City Iron Wks., Erie, Pa.
F. W. Dean, Cons. Engr., Boston, Mass.
Wm. F. Kiesel, Asst. Mech. Engr., Penna. R. R.
Arthur M. Greene, Jr., Professor of Mechanical Engineering, Rensselaer Polytechnic Inst., Troy, N. Y.
Charles E. Gorton, Gorton & Lidgerwood Co., New York.
Elbert C. Fisher, V. P. & Gen. Mgr. Wickes Boiler Co., Saginaw, Mich.
C. W. Obert, Assoc. Editor, Am. Soc. M.E., and Secretary to the Boiler Code Committee.

The work of revision was begun on December 15, 1914 and has continued without interruption since that time. It has involved numerous conferences with

organizations and interests in order to settle satisfactorily the few remaining questionable features. It is also worthy of note, that the attendance by the members of the committee has been unusually large in view of the protracted period over which this work has extended (over six weeks continuously).

The work of revision is now rapidly approaching completion, and it will soon be possible for their report to be presented to the Council. If the report meets with the approval of the Council, it will be printed at an early date.

## E. D. LEAVITT MADE AN HONORARY MEMBER

Erasmus Darwin Leavitt of Cambridge, Mass., was elected an Honorary Member of the Society at the meeting of the Council on January 12, 1915, in accordance with the vote of the membership by letter ballot.

Mr. Leavitt, who was the second President of the Society and served it during one of the most difficult periods of its early career, was born in Lowell, Mass., October 27, 1836. He was assistant engineer in the United States Navy from 1861 to 1867, and was consulting engineer for the Calumet & Hecla Mining Company from 1874 to 1904. He has also acted as consulting engineer for the cities of Boston and Louisville, Ky., and for Henry R. Worthington and others.

Mr. Leavitt is a member of the American Institute of Mining Engineers, the Boston Society of Civil Engineers, the American Society of Naval Engineers, the British Association for the Advancement of Science, the Franklin Institute, the Institution of Civil Engineers and the Institution of Mechanical Engineers of Great Britain, and is a Fellow of the American Academy of Arts and Sciences. He was awarded the degree of Doctor of Engineering by Stevens Institute of Technology in 1884.

## DR. BRASHEAR PARTICIPATES IN THE TRANSCONTINENTAL TELEPHONE TEST

Dr. John A. Brashear, President of the Society, on special invitation of Dr. Alexander Graham Bell and of John J. Carty, chief engineer of the American Bell Telephone Company, participated in a private test of the trans-continental telephone line from New York to San Francisco on Sunday afternoon, January 24, preparatory to the great gathering held the following day, the events of which are now common knowledge. The lines were connected up with Boston, Jekyl Island and San Francisco, covering a distance of 5000 miles, over which the listeners could plainly hear Dr. Bell in New York talking with Thomas A. Watson in San Francisco. It was Mr. Watson who listened to Mr. Bell in the first message sent over the original telephone.

Dr. Brashear says: "I regard it as a red letter day in my life, although during the past fifty years I have been so intimately associated with the development of science, particularly in the domain of electricity and astronomy and correlated sciences. Wonders will never cease, but this seems to be the climax of great things in electric communication for this century."

## THE MELVILLE MEDAL

Admiral George W. Melville, Past-President and Honorary Member of the Society, who died in March 1912, left in his will a bequest of $1000, the income to be expended upon a gold medal and awarded annually for the best original paper or thesis submitted in competition. It has been decided by the Council that it will be necessary to allow the interest to accumulate for the purchase of a die for the medal before its award is instituted.

## APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before March 10, 1915.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Cooper, Elisha H., Treas., Fafnir Bearing Co., New Britain, Conn.

Dinwiddie, William W., Experimenter, Edison Laboratory, West Orange, N. J.

Farmer, Frank M., Ch. Engr., Electrical Testing Laboratories, New York.

Fleckenstein, Harry, with Hindley Gear Co., Philadelphia, Pa.

Gulick, Henry, Pres., Gulick-Henderson Co., New York.

Hayward, Harrison W., Assoc. Prof. Applied Mechs., Mass. Inst. Technology, Boston, Mass.

Hemmerly, William D., Installation of Scientific Management, The Acme Wire Co., Oven Equipment & Mfg. Co., and Sentinel Mfg. Co., New Haven, Conn.

Lang, William H., Secy. and Treas., Phillips, Lang & Co., Inc., Chicago, Ill.

Mitchell, John R., Representative, W. H. Miner, Chicago, Ill.

Miyakawa, Kunimoto, Engr. Captain, I. J. N., Admiralty, Tokio, Japan.

Munn, D. Walter, Lecturer, School of Mining, Queen's Univ., Kingston, Ont., Canada.

Nichols, George B., Ch. Engr., Dept. of Architecture, Albany, N. Y.

Nolan, Quinces R., Supt. of Constr. and Surveys, Park A. Dallis Co., Atlanta, Ga.

North, Herbert B., Supt., Sentinel Mfg. Co., New Haven, Conn.

Nottingham, Avon R., Prof. Mech. Engrg., Purdue Univ., Lafayette, Ind.

Pearson, Robert H., Cons. Engr., Globe Indemnity Co., New York.

Piek, Stefaan, Genl. Mgr., Niagara, Lockport & Ontario Pwr. Co., Buffalo, N. Y.

Prussing, Rudolph E., Engr., Whiting Foundry Equipment Co., Harvey, Ill.

Skinner, Orville C., Supt. of Manuf., Standard Steel Wks. Co., Burnham, Pa.

Stimmel, Fred C., with The Casey-Hedges Co., Chattanooga, Tenn.

Thompson, John T., Ordnance Engr., New York.

Thurlow, Oscar G., Designing Engr., Alabama Pwr. Co., Birmingham, Ala.

Warfield, William G., Supt., Marion Pwr. Sta., Public Service Elec. Co., Jersey City, N. J.

Warr, William, with Robins Conveying Belt Co., New York.

Wright, George S., Mech. Draftsman and Mch. Designer, Sefton Mfg. Co., Anderson, Ind.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Defppeler, John H., Supt., Goldschmidt-Thermit Co., Jersey City, N. J.

Hickstein, Ernest O., Mech. Engr., Wichita Natural Gas Co., Bartlesville, Okla.

Komow, Maximilian, Instr. Mech. Drawing and Mch. Design, Murray Hill Vocational School, New York.

Miller, T. Lee, Asst. to Pres., Toledo Rwys. & Light Co., Toledo, Ohio.

Rollow, James G., Combustion Engr., Southern California Edison Co., Long Beach, Cal.

Simpson, Ralph, Mch. Tool Designer, Potter & Johnston Mch. Co., Pawtucket, R. I.

Weaver, William G., Lecturer in Mech. Engrg., South African College, Cape Town, South Africa.

FOR CONSIDERATION AS JUNIOR

Boyd, Ernest M., Draftsman, Mathews Gravity Carrier Co., Ellwood City, Pa.

Brooke, William C., with N. S. Hill, Jr., and S. F. Ferguson, Cons. Engrs., New York.

Brown, Albert M., with Sullivan Mchy. Co., Chicago, Ill.

Coldwell, John S., with Alberger Pump & Condenser Co., Newburgh, N. Y.

Field-Frank, Crosby, Cons. Engr., New York.

Hazzard, William S., with Southern Adjustment Bureau, Atlanta, Ga.

Karr, Alfred D., with Tiffany & Co., Silver Wks., Newark, N. J.

Kessler, Raines, with The Terry Steam Turbine Co., Hartford, Conn.

Lockwood, William G., Asst. Ch. Engr., Pierce Phosphate Co., of the A. A. C. Co., Pierce, Fla.

Low, Frederick H., with the Ford Motor Co., Highland Park, Mich.

Montgomery, Graham L., Inspector of Constr., Brooklyn Edison Co., Brooklyn, N. Y.

Nevius, Walter I., Asst. to Steam Engr., Inland Steel Co., Indiana Harbor, Ind.

Pope, Samuel A., with William A. Pope, Chicago, Ill.

Pound, Joseph H., Instr. in Mech. Engrg., Rice Institute, Houston, Tex.

Prest, Harold M., with H. R. Worthington Hydraulic Wks., Harrison, N. J.

Rush, Earl S., Draftsman, Iola Portland Cement Co., Iola, Kan.

Wegener, Francis A., Asst. Master Mech., Welsbach Co., Gloucester, N. J.

Wolfner, Ira W., Asst. Treas., Natl. Cooperage & Woodenware Co., Peoria, Ill.

## APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Hill, Harold H., Mech. Engr. and Dist. Mgr., Erie City Iron Wks., Cleveland, Ohio.

PROMOTION FROM JUNIOR

Hebberd, Loren L., Mech. Engr., Vaughn, Meyer & Sweet, Cons. Engrs., Milwaukee, Wis.

Mudd, John P., Engrs. Dept., The Midvale Steel Co., Philadelphia, Pa.

Rupf, Ernest L., Genl. Mgr., Bayonne Bolt & Nut Co., Bayonne, N. J.

Sowden, Parkin T., Mgr. and Mech. Engr., Standard Silver Co., Ltd., Toronto, Canada.

Yates, Sheldon S., Prin. Asst. Engr., New Haven Trap Rock Co., North Branford, Conn.

## SUMMARY

| | |
|---|---|
| New Applications | 50 |
| Applications for change of grading: | |
| Promotion from Associate | 1 |
| Promotion from Junior | 5 |
| | 56 |

# PUBLIC SERVICE MEETING

*THE feature of the Annual Meeting held in December was the Public Service meeting which required the entire day on Thursday, December 3, and some time on Friday morning. These sessions were arranged by the Public Relations Committee, who desired to draw to the attention of engineers the opportunities for the application of their special training and knowledge to the many important engineering problems that confront the large municipality. The papers and discussion showed the broadening field of work for the engineer and the need for a public-spirited service in civic affairs. There were nine papers presented, which are here published in abstracted form, together with a brief account of the discussion.*

At the opening session of the Public Service meeting held on December 3 during the Annual Meeting, brief remarks were made, previous to the presentation of the professional papers, by the Hon. John Purroy Mitchel, Mayor of the City of New York, by Andrew Carnegie, Honorary Member of the Society, and Dr. John A. Brashear, President-elect.

President Hartness who presided said, in introducing the Mayor, that in other days the engineer was needed in the administration of cities; but the modern city has grown to be a piece of mechanism—the more modern the city, the more complicated the mechanism. The highest type of modern city is the great city of New York and the Society was honored in having its Mayor as a guest.

Mayor Mitchel said in the course of his remarks that while at the present time nearly every one of the great constructive activities of the city was in the hands of engineers, yet there is still great need of assistance in working out the problems of administration, public and civil service, accounting, and all the multiplex activities of a city government represented by its administration departments.

Mr. Carnegie eulogized the work of American engineers and commended the Mayor in his aims in solving the difficult problems presented in city government, concluding with a few facetious remarks at the expense of Dr. Brashear, his intimate friend. Dr. Brashear replied in kind, speaking also of the valuable assistance Mr. Carnegie had rendered in an important research which he had just completed and of the pride taken by the people of Pittsburgh in the great educational and scientific institutions made possible by Mr. Carnegie.

## THE FUTURE OF THE POLICE ARM FROM AN ENGINEERING STANDPOINT

BY HENRY BRUÈRE,[1] NEW YORK

Non-Member

The author states as his reason for a discussion of the problems of police administration at a meeting of mechanical engineers that the most neglected field of public service in America is the police department. There is no part of municipal administration, not itself in the engineering category, that more urgently needs the aid of engineering method than does the "police arm." He makes this assertion on two assumptions, with which, he says, there may not be general agreement. The first assumption is expressed in a definition of the substance of the "engineering method." The second assumption is expressed in a definition of the functions of the police arm. These definitions are as follows:

*a* The engineering method consists of applying scientifically determined knowledge to the execution of a particular problem, and the use of ordered and analyzed facts as a basis for formulating conclusions in respect of that problem. As a result of the repeated application of the engineering method to like or similar problems a technique is established for achieving a particular object repeatedly, with least waste of energy and resource

*b* The function of the police arm of government is to ascertain all the facts regarding the phenomena of crime and disorder, and by the use of those facts as a basis for action, direct and collateral, to minimize and extirpate crime and disorder

In respect to the functions of the police arm the author says that generally, until now, the functions of the police have been assumed to be something as follows:

*a* General enforcement of certain laws and ordinances

*b* Enforcement of certain other laws and ordinances selectively, according to the feasibility of their enforcement and the state of public opinion regarding them

*c* Enforcement of certain other laws and ordinances on complaint of persons injured by their infraction, with particular respect to the perpetrators of the injury

*d* Repression or prevention of crime and disorder, by the process of tacit intimidation; in other words, the brass buttons and swinging night stick

*e* Physical and militaristic suppression of express disorder, such as riots and street brawls

[1] City Chamberlain, Municipal Bldg.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

*f* Investigation of crime committed for the purpose of tracing, identifying and apprehending the criminal

*g* Performance of inspections, regulation of traffic, rendering aid to citizens, and miscellaneous other incidental functions that are committed to the police as matters of convenience, and are not generic to the police problem

The one common ideal of police service that has been developed in American cities is that the police must be physically well-conditioned and personally honest. This is about as far as any American city has gone, with the possible exception of Toledo, under the rule of Brand Whitlock, and New York City today under the administration of Mr. Mitchel and Mr. Woods.

In the minds of the conventional police, criminals divide themselves into four groups:

*a* Aliens, enemies of society violating the rights, safety and peace of a community, "to be put away," thus gotten rid of

*b* Native incorrigibles, endowed with natural perversity, namely, the familiar thug, the gangster, the crook

*c* Fortuitous criminals who become subject to police action because of moral lapse or temporary aberration

or as belonging to

*d* A miscellaneous group including special and individual cases too numerous to catalogue, but comprehended generally in 174 items of the standard crime classification, as used, for example by the New York police

There has been no recognition of crimes as the consequence of remediable social conditions or the effect of individual abnormalities, either physical or mental, resulting from removable causes.

There should, however, be a statistical basis for police work, as there is a statistical basis for engineering work. There is nowhere in the world a collection of social data so potentially useful to the development of a community as lie in every great municipal police department, in the records of arrests, in the records of crime disposition, in the investigation of crimes, in the notebooks of policemen and in the memoranda and reports of detectives.

In the report of the New York police department for 1913, the only reference to these records is found in a single sentence under the heading Bureau of Records:

> During the year 1913 there were received and filed in the Bureau of Records a total of 35,013 documents.

New York City employs 11,000 policemen who made 119,736 arrests in 1913. It has a detective bureau of 150 detectives who investigate 55,000 cases of crime a year, but it has not a single employe engaged on an analysis of the facts brought into the archives of the department in the form of reports on investigations and records of arrests. Commissioner Woods is the first police commissioner in America, so far as the author knew, who has thought it worth while to put in his budget a request for statisticians. Next year he will have a statistician under the supervision of a deputy trained in statistical analysis, who will study current police conditions and police work. Not only is he taking this step, but he is utilizing every member of the force as an agent for gathering social facts respecting such matters as unemployment, destitution, improper guardianship, upon which intelligent police work must be predicated.

While it is generally known that economic distress and unemployment lead to an increase of small crimes against property and the breakdown of natural self-control, no American police department has ever analyzed its records to correlate degrees of unemployment with perpetration of crime, and thus furnish the basis for police activity with regard to unemployment. New York City, however, has had this matter forced upon its attention. Conditions of unemployment last year furnished the opportunity for anarchistic agitation, demonstrations of violence, invasions of churches and other disorderly practises, on the avowed theory that only in this way could the public be brought to realize the crucial importance of unemployment conditions.

These violent manifestations of disorder, which had their relation to conditions of unemployment occurring in 1914, make it seem a natural function of the police to ascertain the facts regarding conditions of unemployment in 1915. The police department is the logical agency to call the attention of the community and other branches of the government to the need for taking some constructive steps to mitigate abnormal unemployment.

In New York, one of the principal problems confronting the police is control of traffic. It was never conceived by the builders of modern cities that thoroughfares, intended for residential purposes and often crowded with children, would be utilized by high powered motor trucks and automobiles, and that many streets designed for local traffic would become the thoroughfares of a vast population. As a result of this condition there are killed each year in the streets 445 persons.

It is peculiarly the function of the police department to work out means of preventing this appalling condition, because the police department is charged with responsibility for regulating traffic. Up to January 1st of this year, New York City's police did not record information necessary for an intelligent analysis of the conditions surrounding the death of persons in the streets, although they are required to report the facts regarding each occurrence as a part of the coroner's investigation.

By focusing the attention of police captains and patrolmen on the incongruity of using congested traffic

streets for play spaces for children, the present police commissioner obtained from patrolmen and their officers suggestions concerning the use of vacant lots for play purposes and for closing to traffic during certain hours of the day streets used by children for play. The mere fact that the police themselves formulate such suggestions and assist in putting them into effect, brings about a psychological change in the attitude of the policeman to his community relationships which is full of the greatest possibilities for the development of police service. It is merely another illustration of applying the scientific or engineering method to a particular problem, instead of continuing along from year to year, from generation to generation with fatalistic resignation to whatever may happen.

The author anticipates possible criticism of his suggestions that they overlook the necessity for dealing with criminals as criminals and maintaining law and order by vigorous police action. It is no part of this suggestion that law enforcement be relaxed. A sentimental attitude towards breakers of the law and violators of the public peace and social rights of the community is not advocated. On the contrary, a very drastic action is favored regarding them where such action does not defeat its own purpose. It is recognized that the existing product of social environment, of disease, of mental degeneracy, of moral perversity, cannot be dealt with through eliminating conditions which breed them, but have to be dealt with through our penal machinery, and will probably sooner or later, for the protection of society, become the subject of police action.

A very considerable part of present criminality can be eliminated by intelligent preventive action. This preventive action should be initiated, if not actually taken by the police. To initiate it intelligently, the police must act not on general information or impressions, but on carefully gathered data. These data will not in every instance point to clear conclusions or be capable of definite analysis. The work of correlating crime to social conditions is practically untried. If law and order lie at the basis of industry, if social adjustments are essential to economic welfare and civic development, then no section of the community can ignore the police problem. It is particularly important that engineers who are the expert advisers of our industrial and economic life should make their special experience available to police administrators in formulating a method for arriving at the facts underlying the police problem.

The latter part of the paper deals with police organization. Involved in this are questions of training of officers; selection of officers; ratings for efficiency and selection for promotion; enforcement of discipline; methods of compensation; welfare activities, including educational work, medical supervision and provision for insurance and pensions. These various questions are discussed briefly. The author says further:

The outstanding fact regarding conventional police organization is that it is military, and the outstanding fact regarding military organization is that it is not intended to accommodate itself to shifting social development, to relate itself intimately to community life, to be sympathetic and understanding, or to be flexible. Military organization deals with individuals as subservient members of a group and not as self-governing factors coöperating in the execution of an undertaking. In police departments it has aimed at the one consideration everywhere recognized as fundamental in police work, namely, personal integrity. The military assumption of moral and mental dependence of subordinates on superior officers, has, however, been one of the great weakening forces of police work. In the case of policemen, personal integrity results from exercise of self-restraint in inhibiting an impulse to accept a bribe, to connive at a violation of the law, or to practice extortion. The faculties needed to resist temptations of this character must be developed through a process of self-reliance, through a formulated, even though rudimentary, philosophy of personal conduct. The soldier ceases to be responsible for his moral conduct once he places himself under the command of a superior officer. This condition, while of course less marked in police service than in a purely military organization, still prevails to a certain degree, and has been a conspicuous embarrassment to the development of individual police initiative in larger American police departments. Mr. Woods, New York's present police commissioner, has no military training or sympathies, and is dealing with the officers and men of his department on the assumption that they are self-controlling and self-initiating centers of police thought and police work. This method is a promising contrast to the policy of the martinet, or a policy of easy tolerance, that customarily prevails in police work, and stands out against the old conditions as strikingly as the modern, enlightened employer's policy in industrial management does against the old time shop boss method of dealing with workmen.

The future development of the police arm, if police work is to be constructive and to fulfill its possibilities, must be along the lines of the engineering method. The police department through its multitude of agents is the best equipped of all social agencies for apprehending sympathetically and certainly those adverse social conditions in the community which can be remedied only through community attention. The police department should be the eyes, ears and feeling fingers of the city government. If it finds through its investigation and observation that recreation facilities are inadequate, that this bears upon crime conditions and the welfare of the city's youth, those facts should be driven home to the educational and recreative departments, and in the same way with other conditions.

The police department of a great city should be the nerve center of the city's government, capable of acting with vigor when a situation demands vigorous treatment, strong to protect the safety of the public against disorder and the unruly, informed on conditions which manufacture crime and criminals, in order that these conditions may be remedied where remedies are possible; aggressive instead of defensive, courageous instead of fatalistic, organized for achievement instead of for mere opportunism, militant but not military, except in the sense of obedience to necessary rules and responsive to discipline; free to deal honestly with conditions in the light of those conditions instead of in the light of statutes written by dead hands; coöperating intelligently with charities, corrections, health, hospitals, and educational departments.

To bring these things about the police problem must be broken up into its proper functional divisions. Crime when perpetrated by professional criminals must be dealt with differently from crime committed by those who stray temporarily from the paths of rectitude. There should be organized a national service for the detection of criminals and crime prevention along the lines of similar service now engaged upon forestalling and detecting counterfeiters. The voice of the police department must be heard in the courts when punishment is meted out to criminals, not because it is the police department, but because it is informed and expert on questions of penology.

Above everything else back of police work there must be developed a scientific spirit, the true engineering spirit: in place of cunning and cudgels there must be substituted a policy based upon a knowledge of needs, standards of service feasible of attainment and organization devices to accomplish them, methods of administration and the plant to facilitate their accomplishment, and the genius to capitalize the initiative and individuality of every man on the force.

## DISCUSSION

R. P. Bolton congratulated the author on the discovery that there is a purpose in engineering methods and that there is also the possibility of advantage to one department of city government in the utilization of engineering methods.

The rights of a citizen extend to the exercise of police powers on the part of any individual, and the police are no more than paid delegates of citizens performing this duty for them. The question as to whether these men should be regarded from a militaristic or departmental view has more than one side, the advantage of military organization consisting in the addition of *èsprit de corps* to the moral character of the police officer, while the provision of weapons is of dubious value, and certainly tends toward suggestive imitation on the part of other persons.

The author's suggestion that the police should be charged with the study and dissection of the causes of crime would lead to doubtful results, since the work is in itself a function of scientific investigation, and the local police would be confined to the study of local causes, which might be misleading. The proposal would only result in additional jobs in scientific bureaus added to the police department, and publicity given to such statistics and information might have an unfortunate result in suggestive inducements to crime.

Some at least of the accidental deaths in the public streets are due to the neglect on the part of our Department of Public Works to provide proper isles of safety, in view of the crowded conditions of traffic.

The author spoke of the prevention of crime by the provision of ample street lighting, but has himself taken a personal part in the recent reduction of city lighting, in the interests of a parsimonious economy.

He believed the difficulties experienced in upbuilding the character and in extending the usefulness of the police force are attributable to causes entirely different from those advanced by the author. He had found a feeling prevailing among the men that they are denied a recognition of loyal service on the part of their superiors and of the public, and are subjected continuously to unfair treatment by politicians and by the newspapers, and also that the magistrates almost unanimously seemed to regard a police officer as either a liar or a scoundrel.

He agreed with the author as to police pensions, but pointed out that this condition is applicable to all classes of city employes. The essential error in this system lies in the provision of pensions paid to idle men still capable of work. The process should be entirely changed, so that increasing age should be met by a proportionate reduction of labor and not by payment for idleness, and the value should be recognized of the continued service of experienced and faithful employes long after their full physical capacities could be exercised.

The application of engineering methods to the problems of the police would include the recognition, prior to the question of efficiency, of the value of loyalty, of merit and long service, and also the establishment of a system of fair treatment of the members of the force.

Clement J. Driscoll[1] in a written discussion said that the cause for police inefficiency in New York can be found in the fact that in 13 years the department has had 10 police commissioners. Not one of these doubted the efficiency of the engineering methods and not one did not fully realize before he retired, or was forced to retire, from the department that the police problem was such that only careful, patient application of scientific methods would solve it. All of them would say to the engineers gathered here that all the methods known to science would be of little value while the control of the department was in the hands of the political powers of a community. The Panama Canal, one of the supreme engineering feats, was made possible only because the engineer in charge remained on the job long enough to work out the engineering problem. But even Mr. Goethals would not have mastered the police problem of New York by the application of the engineering method if he had been subjected to the conditions under which all the administrative heads have had to work. No matter how determined a police commissioner may be to keep his department free from politics, it will be subjected

[1] Bureau of Municipal Research, New York City.

to political influence so long as he himself is subject to arbitrary removal and the mayor of a city is held responsible for a police department and its management.

In summarizing, he urged as the first step toward increasing the efficiency of the police, the adoption of statutes providing for a more permanent tenure of office for the administrative head; second, the complete separation of the police department from the mayor's office, placing the full responsibility for the administration and conduct with the police commissioner or administrative head, regardless of his title; third, the application of the engineering method; and, fourth, the complete abolition of the system now in vogue throughout the country of adopting policies of law enforcement which will result in the enforcement of the statutes as written.

ALEX. C. HUMPHREYS said that his chief reason for speaking was to pay a tribute to Mr. Bruère, and to say that he was sorry that the discussion could not have been more appreciative of Mr. Bruère's courtesy. He said there was no fundamental inconsistency between Mr. Bruère's paper and Mr. Driscoll's discussion, though some other inconsistencies are apparent in connection with the discussion. He suggested to the New York citizens present that they had better not take upon themselves the task of being their own policemen; they might get into trouble. They can, however, advise and they can educate the public as Mr. Bruère had advised, and here he differed from the last speaker. He saw no reason why Mr. Bruère's suggestion with regard to a bureau cannot be carried out. The direction would have to be in the hands of a man qualified for scientific investigation. Under such direction of such a man the facts could be gleaned from the rank and file of the force. This would involve no inconsistency but might be a tremendous agency for the education of the public; and if the public could be sufficiently educated, the politics of the situation would be taken care of. The speaker said that he agreed absolutely that the present troubles in connection with police control are largely due to the interference of politicians.

The AUTHOR disagreed with Mr. Driscoll in saying that the greatest difficulty in this matter is politics. There is no politics in the police department for political reasons. The reason is that the police department does not know what the gang problem is. The thing that is most needed is not the elimination of politics, but more of the kind of politics that men such as the engineers present would uphold.

In answer to Mr. Bolton, he did not recall having suggested that a new bureau be established. He suggested that there be given to the police department the facts regarding outside conditions, not gathered by impressions, but based upon the actual experience of the department. There is no problem which Mr. Bolton has ever been called on to face that he does not or should not reach in the same way. And in engineering questions, the question of lighting public streets, in which he has an interest, cannot be solved by a general assumption that a lot of light is going to reduce crime. On this theory one can get ten times too many lights. Lighting under such circumstances may not reduce crime at all, but simply add to the payments made by the city to the lighting company. In settling the questions of lights and of gangs, the police department has to approach the problem just as any engineering question must be approached. If gangs exist because they have the protection of politicians, that cause ought to be ascertained.

His plea was that we proceed with regard to this whole question on the basis of facts, not on that of passion or sentiment, or of politics, or of impulse or judgment. He asked engineers not to find a way of putting on the shoulders of others the responsibility for existing conditions, but to take it on their own shoulders. To have, as some one suggested, a police commissioner continuously on the job would not mean success in police administration. He could not understand his problem merely by continuity of service, but would have to employ the engineering method advocated by the author.

He hoped that as a result of this conference some thought would be given in each community represented to getting a fact basis for police administration, so that in dealing with this most easily complicated division of city government we shall not have to act merely upon passion, impulse or newspaper headlines.

# SOME FACTORS IN MUNICIPAL ENGINEERING

BY MORRIS LLEWELLYN COOKE,

PHILADELPHIA, PA.

Member of the Society

The author calls attention to the wide opportunity for the activity of engineers in municipal work and to the fact that at the present time a large part of this field is either not covered at all or covered by non-technical men. The author emphasizes, however, the necessity for the cultivation on the part of the profession of a broader and more collective interest in public affairs. In this he follows up the theme advanced in a paper read some years ago before our Society under the title "The Engineer and the Public." There is a note of warning that with the growing consolidation of manufacturing and other enterprises, especially in the utility field, there is danger that the cities of the country will be left without proper engineering advice in certain of their engineering questions. The author points out that the matter of viewpoint and a genuine public interest are as essential in the engineer who is to advise a city as ability and experience.

An important part of the paper is the author's reference to the function of advertising, both as affecting the professional activities of the engineer and in the movement to educate the public to the necessity for having public work done on an engineering basis. He holds that certain kinds of municipal engineering, street cleaning for instance, are based on a growing appreciation on the part of the public of the factors of the problem and that this

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

can only be developed through systematic and aggressive advertising methods.

The effectiveness of the engineer in public employ is very largely dependent upon the support given to him by his profession in the education of the public to proper policies of administration. The engineer holding a public position is not "in politics" and to be a success must have the collective support and advice of his profession. There are too many matters that should be determined by technical and scientific considerations now decided by vote. Attention is called for instance to the archaic systems of appropriation and control of the budget now in general use in our municipalities with suggestions for remedies.

Civil service as it applies to filling the higher technical positions is referred to and a note of warning sounded as to the growing complexity of all governmental problems. Lines along which municipal agencies may be simplified are indicated, and a suggestion is made for a municipal reference library as a branch of the Engineering Societies' library.

Quotations follow from different sections of the paper:

The test by which the role of the engineer is to be determined will be the development in our profession of a genuine spirit of public service. The community is apparently ready to accord the engineer a leading, perhaps a controlling part, if the engineer will consider that in every decision and act there shall be the clearest possible recognition of the public interest. We should remember that democracy can use the engineer without giving him either a leading or a controlling hand in affairs. This use of engineers has been conclusively demonstrated by public utilities companies, especially during the last thirty years. In most of our larger cities during this period there have been operating one or more so-called "big business" men who have built large fortunes and a certain kind of fame in the development of enterprises in which engineering was an important factor and in which it should have been the paramount and controlling factor. In these enterprises engineers have necessarily been used, but not in a leading or controlling capacity.

It would probably require considerable research to get the names of the engineers used by Charles Yerkes in Chicago; by Martin Maloney in Philadelphia; by Anthony N. Brady in New York; and by Patrick Calhoun in San Francisco. As a profession we may as well face this problem and decide whether in the further upbuilding of our cities, we are so to serve democracy as to be warranted in demanding and to be entitled to receive a position comparable to the real importance of our work.

That profession which considers only its own and its clients' interests without a proper regard for those of the general public will be accorded the same position which history has always given those who are led by no higher star than self interest, however enlightened that self interest may be. I firmly believe that the engineering profession is rising to meet its broader responsibilities with perhaps an even more quickened pace than that which during recent years has wrought such sweeping changes in the medical profession and that of architecture. There are certain kinds of engineering in which financial and almost all other kinds of preferment depend on an attitude of mind which, while not necessarily anti-social does not provide sufficient opportunity for entertaining a virile public point of view.

As a representative of public, rather than private interest, it is my duty in choosing the advisers of the city, which I have the honor of serving, to satisfy myself not only as to the ability of those we employ, but also as to their disinterested—yes, their public point of view.

No matter how able a man may be, how broad his experience nor how high his standing, his service to those who employ him must at all times be consistent with the public interest if, from my point of view, he is to be available for public employment.

Judged by this standard, there are in certain fields of engineering almost no engineers who are at present available for the service of the public and who at the same time have had sufficient experience for large undertakings. In the past few years we have had unusual opportunities for seeing at close range the professional attitude of those equipped with the technical knowledge required in advisers to cities on utility matters. It has been practically impossible to secure the services of those with reputations already made in the electrical field. Some of our experiences could be considered on the whole rather amusing were it not for the fact that we are left under the obvious conclusion that for the average city official to get good advice on these matters, is well nigh impossible. What is more objectionable is that this condition is one quite generally recognized as true by city officials.

I must be careful to emphasize the fact that no criticism of any individual is embraced in these remarks and that I am simply pointing out a danger almost necessarily confronting the engineering of an industry dominated by financiers having no knowledge and little appreciation of such professional standards as engineers are supposed to have.

The same tendency is to be noted in other branches of our profession. An eminent authority on concrete, who is in intimate touch with the men who are practising in this line, was recently asked for the name of an engineer who was not in anyway affiliated with the large manufacturers of this material and after considerable study was able to think of only one man. There is nothing necessarily improper in this situation,—it may simply mean that all the competent men in this line receive retainers from manufacturers. Some months ago I wanted to retain an engineer fully posted on the details of a certain sub-division of railroad operation. It was extremely difficult to find a man without recognized affiliations which would preclude his retention. Again I am informed that there are no asphalt experts who do not receive retainers from the manufacturers. It is a condition which should be provocative of thought by engineers.

Public employers up to the present have been almost a negligible factor in furnishing opportunity for employment or for the making of a reputation. It is perfectly natural, and it is in accord with former ideals that engineers should feel their first duty to be to these private employers. But in this time of broader and deeper social consciousness, it seems to me that this standard must change.

The point I wish to make is that engineering has now reached the stage of development where it has become a profession in the highest sense of the word. The engineer

being a scientist, his responsibility should be for the development of facts, regardless of whose advantage they may serve. I have in mind that the service of an engineer should be as the service of a judge, as opposed to the service of a lawyer who confessedly seeks out and represents the interests of his client, and often "makes the worse appear the better cause." This is justified by the fact that lawyers are not scientists, and by the assumption that there shall always be opposing counsel.

If this municipal field is to be one in which engineers of ability, sincerity of purpose and high ideals are to find a permanent and satisfactory outlet for their energies, our profession acting as a profession will be one of the main agencies bringing about certain fundamental changes in the attitude of the public. In the minds of too many engineers, participating collectively in matters pertaining to municipal engineering means "getting into politics." Architectural work being a part of the business of The Department of Public Works in Philadelphia, we have had the coöperation of the American Institute of Architects and of its Philadelphia chapter from the beginning. . . . We have had the constant, indefatigable and valuable support of the secretary of The American Society of Mechanical Engineers in our efforts to maintain the highest professional standards in the work of the department. But engineering bodies as such have given us no assistance and so far as I know have taken no part in the discussion of federal, state and municipal engineering, except in the matter of conservation which for some reason is considered as innocuous as a prayer meeting.

Many municipal engineers in this country are beginning to adopt the European system of employing non-residents for certain highly specialized positions. Whenever this is practised it excites criticism and abuse. As yet no technical organization, so far as I know, has recognized the opening thus made for technical merit and given moral support to the movement. Again I have tried to get support from organized engineers in the obviously necessary procedure of employing experts outside our regular staff, but without results.

The public must be taught that public service is not different from private service in that forward steps come frequently, even usually, as the result of a large amount of preliminary investigation. Again, the public, of which please remember we are a part, must be educated to place more responsibility on individuals, thus making it possible to do away with the great inefficiencies which inevitably accompany board and committee management. As long as we have boards and committees they will vote,—and they will insist on voting,—on matters that are not questions of personal opinion but questions of facts which ought to be determined by the facts. It is one of our duties as technical men to carry on a propaganda which will show to the public the difference between those problems of policy and public interest, that are properly settled by public opinion and those scientific problems which are improperly settled unless they are settled according to the facts. Mr. Frederick W. Taylor, Past-President of the Society, in recent lectures has very forcibly and lucidly suggested this fundamental difference. For instance, my opinion may be as good as that of any other citizen's as to how fast an automobile should be allowed to operate in different sections of a large city. The opinion of any member of this Society is as good as that of any other citizen as to the penalty which should be inflicted for false registration. On the other hand, the designs for a bridge; or the specifications for a sewer; or the plans for the laying out of a public park; or the organization of the police department; or the fighting of fires; or the elimination of mosquitoes are necessarily the work of experts. Such work will always be indifferently done if done by voting; whether the voting is by the people at large or by a committee or board acting for the people. Notwithstanding all the boards and commissions that are created in the generally approved laws of today, there should be no uncertainty as to what questions they may vote upon. It is therefore one of the duties of the educated to carry this message to the people and in doing so I do not think there will be any more powerful method than to give the great mass of the people a larger and larger knowledge of expert work.

I am not one of those who feel that all our short-comings are "the fault of the people." I would rather assume my share of the responsibility for conditions as they are and then join with my professional associates and the community at large in bettering them. If we engineers are to have any prominent part in this there are fundamental changes which we shall have to make in our own equipment for the work. In the first place, we have to get rid of the now old-fashioned idea that advertising is a crime. I admit that as a part of my work as a public official I put in a great deal of thought on what may be quite properly called advertising. By that I mean that I pay less attention in my reports to dignity of form and diction than to making them sufficiently interesting to be read. It is only as we engineers who are public officials learn to make the public, sometimes against its will, understand our work, that we are to get that degree of popular support for it which will make it possible for it to be done in an efficient manner.

In my opinion it is going to become more and more a necessity, not only in public but in private work, for engineers to be able to popularize what they are doing. It is true today that a man who wants to do really good and efficient work can do so only after an aroused public opinion. You cannot drive people in a democracy. So I admit that in offering employment to an engineer, other things being equal, I want what might be called a good advertiser. You can secure appropriations for work more easily when it is well advertised. The Panama Canal is a good example of this principle. Again, advertising is the best possible check against ill advised expenditures. In building our Byberry and Bensalem Service Test Roadway we erected sign-boards on each of the 26 sections giving to the layman the exact method of its construction in non-technical language. If the public knows how a street is supposed to be constructed or cleaned, you do not require as many paid inspectors on the job.

The development of some varieties of municipal engineering is absolutely dependent upon the development of public opinion and must proceed with it. The matter of street cleaning is largely a question of an improved public taste in the matter of street paving. Unless streets are well paved they cannot be well cleaned except at a prohibitive cost. To jump from one degree of cleanliness in this respect, to another, without a supporting public opinion, may be enough to wreck an administration and to set the

tide of civic improvement running in the opposite direction.

The newspaper is the great educator in these matters today. But we are already using in Philadelphia moving pictures, parades and exhibitions. The possibilities of these and other means of publicity are not yet fully understood.

Take, for instance, the movement which has led to the formation of large numbers of business men's associations and improvement associations. This affords one of the very best examples of the present vitality of American public life. Our leading men should accept them as something that has come to stay and coöperate with them in such a way as to direct their activities into profitable channels. It seems to me they afford the most promising agency through which in the first place, the thought of the public on civic questions can be crystallized and secondly through which that thought can be given expression in definite public procedure. I have found these associations ready and anxious to hear from men who had definite knowledge on matters of public interest. It should be the attitude of any engineer who wants to play his part in the community, to affiliate with one of these organizations and to help to make it an influence. You can rest assured that the man who is in public life for his own personal advancement is bending every energy to defile and degrade these institutions and to divert them from the high mission which they have it in their power to carry out, so they need our help.

In such a discussion as this, one cannot ignore the civil service. It is always a pleasure to say that personally I could not hold public office if it were not for the safeguards and reliefs that our Civil Service Act affords. At the same time without repeating what I have said in other public papers on the subject, I want to call attention to one fundamental misconception under which the entire civil service question in this country apparently rests. Civil service appears to be founded on the theory that the best man for the position will apply for it. I think it is the experience of every employer of men—and this is especially true in filling the higher positions—that the best man will not apply. On the contrary you will usually have to go out on the scriptural highways and hedges to find the best man and then having found him, fall on your knees and beg him to accept the positions offering such opportunities for public service and professional independence as are most likely to secure him.

This is the way to get good public servants. It is almost impossible to find men who have many of the qualifications for our work combined with a willingness to enter the public employ. Even if public employment should come to be considered more desirable than it is at the present moment, I think that this difficulty in finding the best man would still be encountered. Therefore, if we are to have the highest class of men in important engineering positions we must develop some merit system by which the appointing officer is given a greater opportunity than he now has of finding the man for the job. In this work it is impossible for our engineering societies to take an important part.

I believe, for instance, that if the secretaries of the four national engineering societies could be authorized by their several councils to associate themselves as a civil service board to act in an advisory capacity to federal, state and municipal civil service commissions, it would be a decided step in the right direction. Suppose the president of the Borough of Manhattan should want to secure a competent engineer to put in charge of the highway department. Through the New York City Civil Service Commission he would state the problem to this suggested advisory board which in turn would appoint say three engineers to act as his counselors in finding the man. The appointing officer would keep these counselors in touch with the search and when he was ready to make a choice, secure their approval before entering into a contract. In this way the merit system would act as a check against favoritism but would allow the appointing officer the widest possible opportunity to search for the best man available.

This procedure is a radical departure from the present idea of civil service, which is based on the assumption that it is impossible to allow the appointing officer to have anything to do with the selection of his men. Even under the most advanced forms of civil service the appointing officer is confined to a full statement of the qualifications he is trying to secure. One never exactly fills a position with just the kind of man in mind when the search started. It is a question of compromise and the appointing officer is the one who is in the best position to know where concessions can be made and which among the several requirements are the most indispensable. There would be no objection to a check on this action of the appointing officer through some kind of a written test. But to choose men for positions paying $5,000 to $25,000 a year on the results of a written examination is absolute folly. So far as I know engineers have never taken a hand in the discussion of methods under which engineers shall be chosen for positions in the public service and it seems to me high time they should do so.

Among other subjects in the paper not covered in the foregoing extracts is that of records of data upon investigations and work accomplished by municipalities. Not only are such records very meagre, but they are practically unavailable except to those who make them. As a practical suggestion, the author believes that a distinct contribution which the Engineering Societies could make to the solution of the question would be to establish in the library a section devoted to a Municipal Reference Library. At the present time there is no possible way for a city official to be sure that manuscript reports on engineering matters will be available twelve months after they are made. The author had, for instance, a digest on American street cleaning methods prepared by Day & Zimmerman, Consulting Engineers. It is an exceptionally valuable document. He knew where it was today but there was no possible machinery provided in Philadelphia or in any other city whereby officials could be sure that they could find such a report a few months after its preparation. This manuscript would be of very great value to any city official charged with the problem of extensive street cleaning. He would be glad to deposit this report in any library properly organized to receive it.

The same is true of literally dozens of reports on gas, lighting, electricity, garbage disposal, city plan-

ning, police discipline and others prepared under the present administration in Philadelphia. He knew that, if this suggestion was adopted and such a library was started, city officials all over the country would be glad to have extra copies made of every report which should properly belong to such a library.

## DISCUSSION

Alex. C. Humphreys said that while he was in sympathy with much of that presented by Mr. Cooke, he differed from him strongly as to details and in so doing he was guided by a wide experience with engineers and municipal governments.

He believed there was not the slightest difficulty in getting the right kind of engineers for the work referred to, if they were properly approached and fairly treated. If, on the other hand, one approached these men with the idea that because they have been in a certain line of work, they must necessarily be biased in their opinions, one should not expect to get the best results.

The speaker was unable to understand why it should be recommended that a library on municipal engineering should be set apart from the rest of the library. If this should be done for municipal engineering, why not for all other branches of engineering. Then, where should the lines of division be drawn. He was reminded of the advice he had given some time ago regarding a certain book on the finances of public utilities. This book was misleading in the hands of the uninformed by reason of its plausibility. The advice given to those directly concerned was to purchase the book and so be prepared to controvert its false teachings, particularly as this could be done through its own inconsistencies and contradictions.

As to the absence of standards, the speaker thought that the trouble in large measure was that sufficient attention is not given to the fact that working standards can be established only by taking all factors into account; the scientific, upon which there is so much stress laid, and also the practical factors, including the necessary limitations of application,—the commercial, the financial, and the human.

If standards are being developed for the guidance of others, such work must be done cautiously and with a keen appreciation of the responsibilities assumed. Enthusiasm alone is not only not sufficient but may be most dangerous. Those who undertake this work must first of all be competent to do it, and then must secure the faith of those in control with regard to their integrity. The speaker was emphatic in saying that he resented the pervading tone of the paper, which seemed to imply that because an engineer has been in the service of public utilities he is not to be relied upon to give honest advice in connection with public affairs. He did not believe this to be true of the great majority of the engineers of the United States. He believed that those who made such an accusation were unworthy of a place in the profession.

E. H. Merriam said that every engineer engaged in public work should have in him some element of the salesman with a keen appreciation of the need of educating the public to the necessity and importance of the work which he recommends.

He cited the experience of Dayton along this line. Subsequent to the great flood of 1913, two million dollars was subscribed in order to prevent a repetition of the disaster. Engineering corps were put into the field to make investigations, but the progress was slow and the public, in particular as represented by the newspapers, became dissatisfied. It was decided thereupon to appoint a publicity man, a young engineer with some publicity experience, who would give to the newspapers the facts in the case. The false impressions were corrected and the public given the information it needed.

R. P. Bolton said the fact that engineers are engaged in certain lines of commercial work is no bar to their doing independent work and expressing independent opinions, whether they are employed by a municipality or by a private corporation or person. He objected strongly to various reflections throughout the paper, such as that on the work which has been accomplished by large business interests in this country and the suggestion that they should be limited to a certain kind of fame, and that no other credit be given to them. Nor did he see why the author should reflect on the engineers employed by financiers of that wonderful electrical industry which has set the highest standard of engineering of any other industry. The suggestion that our Society should take part in recommending or suggesting the names of engineers for appointments to municipal employment is one that has been considered adverse to the policy of our own and other societies, but a number of societies, including the leading ones, have urged the appointment of engineers as members of Public Service Commissions. Why was not that done in this city? Because the lawyers, who have swallowed practically the whole of the political positions in the State and the city, are afraid of engineers. They do not recognize what an engineer is and what he stands for. The conspicuous and highly talented lawyer who was at the head of the Government at that time stated that he did not appoint engineers because they were always technical, and in his opinion a lawyer could always grasp enough of engineering matters to understand a technical question. He did not believe that the best class of engineers could be brought into the position of taking office under municipal conditions as they are here today. However, he did agree with the author in saying that engineers as a body should take a greater interest and a greater part in municipal affairs; and with Dr. Humphreys and others in saying that engineers will not do their full duty until they recognize the fact that they are not only engineers but are citizens.

H. S. Person[1] presented a written discussion, taking up various phases of the subject of Mr. Cooke's paper. He said, among other things, that nowhere had he heard a cleaner-cut, more challenge-like utterance in this great movement than that of the author's. Mr. Cooke has been to the frontier on scouting duty, so to speak, and now returns with his report. It is at the same time an entreaty and an exhortation for the main army of his professional associates to lift up their eyes to see the problem, the opportunities and needs which he has seen in municipal administration, the field for public service particularly de-

[1] Amos Tuck School, Dartmouth College.

manding the expert knowledge of the engineer. The response should be in the form of definite plans.

These plans must embrace two main lines of operation, education of the public and of the profession. The public needs education concerning the capacity and adequacy of the engineering profession for public administration; the engineering profession, paradoxical as it may seem, needs to educate itself concerning its incompleteness and inadequacy for that service.

For such self-education, the essential requirements are two: the breaking away from the attitude of mind molded by the motive of private gain and the achievement of one molded by the motive of public service; and the development of the special science of municipal engineering. The municipal engineer must be a composite of engineer, economist, educator, accountant, statistician, executive and administrator.

In furtherance of the second phase of professional education, he agreed with the author as to the wisdom of devoting a section of the library to a Municipal Reference Library.

Chas. Day sent a written discussion in the course of which he said: It does not seem possible that our membership should do otherwise than accord the fullest support to those measures which will bring about the highest professional standard in the field of municipal engineering. Today we occupy the indefensible position of permitting without protest the perpetration of obsolete, inefficient and extravagant methods with regard to municipal work involving the expenditure of millions of dollars. It seems to me that it is entirely incompatible with a proper code of ethics that we should tolerate the continuance of such abuses without giving voice to a strenuous protest. Of course, in the final analysis little progress will be made until engineers, possessing not only the requisite experience and knowledge but a deep interest in public welfare, are willing to accept municipal posts. This pertains in particular to those functions which are generally assumed by city governments, such as street cleaning, removal of ashes, highway work, etc. Probably very few of our members are engaged upon such work.

There is, however, another great field of activity closely related to municipal work which engages the attention of a large number of our members, in the work of public service corporations. Owing to the enactment of laws providing for regulation, public service corporations in many states occupy a position in relation to the public that imposes quite as great obligations as those devolving upon the departments or individuals who are engaged upon purely municipal work.

There can be no doubt that there is justification for the dissatisfaction concerning the *results which in many cases have been secured* through State regulation of privately operated public utilities. Certain of the men responsible for the policies of such corporations have lacked almost entirely that recognition of the public interest which is referred to by the author.

It may be that in most cases the responsibility for this condition rests directly upon men who are not members of our profession. Nevertheless, this does not relieve us from the duty of asserting ourselves with a view to placing the businesses to which we are the principal contributors, upon an inherently sound and permanent basis.

There can be no doubt that the type of engineer desired by the author will see that justice is done to corporation and public alike through a frank and unbiased consideration of the apparently conflicting conditions. The qualifications which in Mr. Cooke's judgment are necessary upon the part of the municipal engineer, are equally imperative for those who administer our public service corporations, and it seems to me that this Society can do no more important work than to encourage this spirit in every way within its power.

Carl Schwartz disagreed with the author in his references to the difficulties in securing the professional services of engineers for municipal work, and said that he could personally furnish the names of prominent mechanical and electrical engineers not affiliated in any way with large manufacturing or conflicting interests.

The success of engineers in private enterprises is largely due to the fact that financiers have appreciation and knowledge not alone of the professional standing, since a financier is readily able to measure ability by economic results. To secure such results the engineer must not alone be a scientist, as without a good dose of business judgment he would be unfit for any leading or responsible position.

Admitting that the municipal field may not so far have sufficiently attracted the attention of the engineering profession, he thought that the cause and remedy for this condition are hardly to be looked for in the author's paper. He would refer the author to Bryce's American Commonwealth, and specifically the chapter on why the best men do not go into politics, for a perhaps more reasonable explanation. While the author does not claim that the engineer who holds a public position is in politics, still he advocates the value of advertising, and the writer objected to such publicity methods. In his opinion it would be a calamity should the engineering profession accept the suggestions contained in the paper as a guide for the important field of municipal engineering.

Alex. Dow was in agreement with previous speakers who contended that the services of experienced men unbiased by affiliations detrimental to the best interests of the municipality could be secured for municipal work. He referred particularly to those experienced in the use of concrete, in the use of asphalt, and in the electrical industry. He believed that in none of these fields would any leading man fail to give a truthful answer to inquiries or to render a signed report that was strictly honest, provided his time and engagements permitted him to accept such a commission.

Newton D. Baker[1] wrote that there are one or two thoughts suggested by Mr. Cooke's paper which he desired to emphasize. In the first place, the difficulty in having engineers with the public point of view has not been entirely with the engineers. Our American cities have not made city engineering a career in the German sense of that word, and, therefore, men who have entered the city's

[1] Mayor of Cleveland.

service and become proficient find the rewards of their professional activity greater in private employment. They soon reach the highest compensation and official dignity possible, and not unnaturally, are unwilling to arrest either their own development or their own progress by staying in the public service. This situation arises from various causes. Our American cities have only recently come to a realizing sense of the importance of accurate and expert service for engineers. The old theory was that a man who devoted half of his time to engineering and half of his time to politics was a better public servant, or at least more entitled to the job. As a consequence of this the public have regarded their engineers as political placemen and have not been willing to sanction the payment of salaries at all in proportion to those paid by private employers. Before we can expect the engineers as a professional body to change their attitude therefore, we must have on the part of the people a perfectly frank understanding that high-grade professional service cannot be expected out of a charitable impulse, but must be compensated in a dignified, adequate way by the public as an employer, and that men of real ability will not accept the public service if their continuance in it is to be interrupted in the midst of useful work on their part by the mere accidents of political change in the headship of city governments. He made these comments not because he did not think these changes are coming about, but because he thought in justice to the engineers the entire fault should not even by inference be assumed by them, and because he was very anxious to have the people of our American cities realize their share of the burden in securing efficient and high-grade service from experts.

Robert B. Wolf made a strong plea for the engineer in public service. He believed that the engineer was destined to work out the great social problems of the world as well as the industrial problems.

The word "politics" must be made to have a new meaning and the duty of the engineering profession is to make it synonymous with the highest kind of idealistic service. The reason the world must look to the engineer for a solution of these problems is that in the very nature of things his idealism is practical. His grasp of material facts and laws insures an idealism which is workable, and for this reason will be progressive in its accomplishment of social and political reforms. The fundamental, basic reason why we cannot hope to solve our social problems through our strictly religious and ethical institutions is that they are made up largely of men who have little knowledge of natural sciences. While it is true that the higher spiritual laws include the lower and material laws, it is quite true that we cannot hope to use those higher laws intelligently until we first master the lower. It is because it is the engineer's business to know and use the forces of nature that he, above all others, is qualified to solve the great vital problems of our municipalities.

F. W. Taylor wished to correct the impression that might result from the remarks of the previous speakers that the author considered the consulting engineers of the country, and particularly the electrical engineers, disqualified for consulting work for our municipalities because of their employment by the great public service corporations. Careful reading will show that the author does not say this. The author says that he had been unable to obtain the services for the city of Philadelphia of prominent electrical and consulting engineers. This is a statement of fact, for the reply of these gentlemen was, "We are retained by the public service corporations, or are affiliated with the electrical corporations and therefore not in a position to give you the advice which you seek." It is no reflection either on the integrity of these men that they were placed in a position where they could not give their services to the city of Philadelphia. If there is any reflection at all it passes back to the owners of the companies, who in nine cases out of ten are not engineers, but are financiers who believe that if the cities secure the knowledge to regulate rates, it would ultimately be to the detriment of their companies. This view on the part of the companies, Mr. Taylor did not agree with, since a thorough knowledge of the facts on the part of city officials might as readily lead to a rise as to a decrease in rates.

Charles Whiting Baker said that up to a comparatively recent date cities had been rich mines to be exploited jointly by the politicians and by the franchise-owning companies. Now the public is learning that our city governments may be brought up to the standards which have prevailed for many years in England and in Germany by taking advantage of the skill and ability of the engineer. Within the last five years there has been started the most hopeful movement for the betterment of city government service that has ever been undertaken in this country. He referred to the so-called city manager plan of municipal government. This was begun by the city of Staunton, Va., five years ago and there are now some two dozen cities in the United States which have established the office of city manager and have put engineers in charge of the work.

Besides this, it should be noted that in some other cities which have not formally adopted this plan, engineers are taking a leading part in municipal administration. The author of this paper is practically the city manager of Philadelphia and holds the most important position in municipal service of any engineer in the United States.

Robert S. Woodward[1] wrote that he was interested to observe that many of the ideas which Mr. Cooke has brought forward are similar in their import to ideas he had long held. To some of these ideas expression was given in an address read at Wood's Hole in July last at the dedication of a new laboratory of the Marine Biological Association.

He was especially interested in what the author had to say in regard to the necessity on the part of the engineer of going somewhat into politics, in the better sense of the word. Before we can bring about the reform essential to further progress in society the engineer must take a hand at the problems presented. His points of view and his methods must be availed of more and more by society if we expect to make evidently needed progress.

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[1] President, Carnegie Institution, Washington, D. C.

# THE NEW CHARTER FOR ST. LOUIS

BY EDWARD FLAD, ST. LOUIS, MO.

Member of the Society

On June 30, 1914, the city of St. Louis by a majority vote of the citizens adopted a new charter in which the engineering profession is given unusual recognition. The charter provides for a Board of Public Service composed of a president and four directors and specifies that the president and two of the directors "shall be engineers of technical training, of at least ten years' experience, and qualified to design as well as to direct engineering work." The members of the Board are appointed by the mayor and will each receive a salary of $8000 pr annum.

The Board of Public Service has charge of all engineering, construction and reconstruction work undertaken by the city and exercises supervision and control over (*a*), the department of public utilities, including the waterworks and city lighting; (*b*) the department of streets and sewers; (*c*) the department of public welfare, including the divisions of health, of hospitals, of parks and recreation, and of correction; and (*d*) the department of public safety, including the police and excise divisions when so permitted by the State, the divisions of fire and fire prevention, of weights and measures, and of building and inspection.

The members of the Board are appointed for a term of four years and are subject to removal only for cause. Each director is given charge of a particular department under the general control of the Board.

No ordinance for public work or improvements of any kind or repairs thereof, shall be adopted unless prepared and recommended by the Board of Public Service with an estimate of cost endorsed thereon, and the Board is given authority to let all contracts for public work.

The charter provides for a measure of popular control by the initiative referendum and recall. All city officers and employees except those specifically placed in the unclassified service are appointed and advanced under the merit system controlled by an Efficiency Board composed of three members appointed by the mayor. A single legislative body is provided composed of 28 members elected from districts, and a president elected at large. The only other officers elected are the mayor and comptroller, all others are appointed either by the mayor or by the heads of departments or divisions.

The new charter replaced the one adopted in 1876. The Board of Public Service replaces the Board of Public Improvements provided by the old charter, with added duties and responsibilities.

The city of St. Louis has been singularly fortunate in having its public work controlled in the past by a board of six men, the majority of whom have always been engineers, although the charter required only one of the members to be an engineer. The provision in the new charter requiring three of the five members of the Board of Public Service to be engineers is a recognition of the valuable services rendered in the past by the engineer members of the Board of Public Improvements. The writer was a member of the board of 13 freeholders by whom the new charter was prepared.

Presented at the Annual Meeting, December 1914. Paper can also be obtained in pamphlet form; price 5 cents to members, 10 cents to non-members.

# THE ENGINEER AND PUBLICITY

BY C. E. DRAYER,[1] CLEVELAND, OHIO

Non-Member

So far as we know, the first instance of systematic publicity for the engineer and engineering is the work so successfully accomplished by the author of this paper for the Cleveland (Ohio) Engineering Society. This led to the presentation of the paper of which an abstract follows and in which the author first raises the question as to what interest publicity may hold for the engineer. In the first place, the public is deeply interested in the things we are doing. People are glad to know not only of the advance in science but also about the men who make it possible and to give credit where it belongs. If then we can make use of publicity with the definite intention of placing the engineering profession in a higher position in the vision of our employer, the public, a point of interest has been found.

In the second place, we find an opportunity and duty to render service to the public by giving it dependable information about technical subjects. The ordinary newspaper uses the same reporter to write crime, politics, sport, invention, and technical achievement. An editor of one of our Cleveland papers once gave us as his opinion that one reason why news of an engineering nature does not get into the daily papers is because the ordinary reporter has not the technical knowledge to handle it. News, it must be remembered, is nothing more than ideas and facts put into interesting reading.

Here, then, are the two elements of a bargain. The public and the engineering profession have something to exchange and both sides will receive substantial benefit. The engineering profession will find itself in a better position by having the public appreciate the important service it is rendering; the public will find itself deeply interested in the information we are able to give, because it advances public welfare.

[1] Chairman, Publicity Committee, Cleveland Engineering Society, Chamber of Commerce Bldg.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion; price 5 cents to members; 10 cents to non-members.

PUBLICITY WORK IN CLEVELAND

In the publicity work of the Cleveland Engineering Society, which has extended now over a period of two years, our first step was to get acquainted with the managing editors of the two leading papers in the city. They were told that the Society had about 500 members, many of whom are at the head of large undertakings on which the growth and prosperity of the city depend, and that the Society stood ready to coöperate with them in obtaining such engineering news as would be of interest to the community.

It so happened that the outcoming issue of the Society's Journal contained the report of a special committee on technical education in Cleveland. Naturally, a large number of people in the city were interested in what engineers had to say about their technical schools. Abstracts to make about three-quarters of a column were written, ready to set in type, and were handed to the editors of the two morning papers. They were printed without alteration. A third paper printed its own abstract and an editorial. If the committee had something to say which the public would be benefited in knowing, surely 200,000 papers with authentic information were a better medium than the 1500 copies of The Journal read largely by technical men.

Another subject of great interest to the public, although it might not appear so from the title, was discussed in R. H. Fernald's paper on The Relation of the Gas Producer to Low-Grade Fuels and Concentration of Power at the Mines. When an abstract appeared in the paper on the Sunday following the lecture, it was headlined as shown herewith:

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**PRODUCER-GAS TO ELIMINATE SMOKE AND SAVE FUEL**

**United States Engineer of Mines Tells Local Society of Broad Conservation Plan**

**MILLIONS OF TONS OF COAL WASTED YEARLY**

**Production of Gas at Mines From Coal Now Unmined Would Solve Problem**

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Reference to the paper printed in the Journal of the Cleveland Engineering Society will bear out the assertion that the headlines do not exaggerate the statements made by Dr. Fernald. Our task was merely to make news of plain facts. To the citizens of any large industrial center like Cleveland, smoke elimination and fuel conservation are mighty live questions. News, as was said before, is the turning of facts and ideas into interesting reading.

Probably the largest service to the community performed by the publicity committee of the Cleveland Society was the publishing of 14 inspirational articles by prominent local engineers on Engineering as Life Work. The articles appeared on successive Sundays in the magazine section of a local paper. Beneath the title of each was an editor's note stating the purpose of the series and that they were published under the auspices of the Society. Among the contributors were two past-presidents of The American Society of Mechanical Engineers and a past-president of the American Railway Engineering Association. The theme of the series was to tell the young man about to choose his life work what is before him in the various branches of the engineering profession. Besides appearing in the local paper, most of them were published in the Scientific American and the Case Tech, the student publication of Case School of Applied Science. Some appeared in other periodicals over the country. A young immigrant wrote to one of the contributors and asked for permission to translate his paper into French and Russian to send to those countries.

While we might multiply instances like the above where our work was distinctly a service rendered the public, we shall pass to an enumeration of the tangible benefits to the Society and to the profession growing out of the publicity work.

A higher standing in the estimation of the people and of those in authority in the affairs of the community is one gain. In Cleveland, the coöperation of the Society is usually sought in the solution of questions of public welfare where engineers are qualified to speak.

To cite an instance, the Civil Service Commission early in the present year asked the Society to assist it by taking charge of the preparation and marking of papers for engineering positions. The first request was for 10 examinations, and the results to both the Commission and to the Society were very gratifying. The Commission secured the service of experts at no cost to the city, but which were worth more than it had available funds to employ. The secretary of the Commission told us that the candidates were satisfied with the fairness of the examination. Concerning previous examinations complaints have been made that proper relative weights had not been given to experience and theoretical training. Our publicity committee saw to it that the public learned through the newspapers of the arrangement between the Civil Service Commission

and the Engineering Society. Credit was given where it was due.

Somebody has said that the public is unreasonable only when it is uninformed. It is hardly possible that any sudden gust of public disapproval would arise where engineers are concerned if the public felt that it was well acquainted with them. When the local society engages in publicity work, a revival in the interest of its members in the activities of the society will be apparent. The indifferent members find they have some pride in their society when its activities, of which they approve, are described in the daily paper. It is said on good authority that the publicity campaigns undertaken by Memphis and Des Moines, to present to business men their advantages for a location, resulted in a renewed city spirit equal in value to the new business acquired.

Due largely to the publicity work, there has been a substantial increase in percentage of attendance at the meetings. One estimate was 15 per cent. To stimulate attendance, the committee furnishes the papers advance notices of the meetings, consisting of a picture of the speaker and some 150 words of text telling about him and his subject.

During the last two years some 250 new members have been added to the roll, an increase of over 50 per cent in a society past 30 years old. Of course, it is difficult to say just what per cent of increase in an organization recently very active in all its functions may be credited to publicity work.

It is possible at this time to know only the general nature and approximate limits of publicity with any degree of accuracy. We can, however, enumerate the various channels by which information of an engineering nature may be placed before the public. It is also possible to give approximate relative values to them. In the matter of choosing mediums we are inclined to lay down this broad general principle: When one man has something to tell another, the telling of which will do them both good, he may employ the most direct honorable means. It may be either the written or spoken word.

Under the written word we would include newspapers, periodicals, such as national magazines, and pamphlets. The spoken word would be confined to a rather narrow field and would consist for the most part of talks by engineers before high school classes, classes in Y.M.C.A.'s, lectures before clubs, at special gatherings in churches and the like.

We have shown that the public and the engineering profession are in a position to make an exchange at a profit to both parties. A record of results in one locality where it has been tried points to what may be expected through coöperation in a larger field. Mediums of exchange have been discussed. There remains yet to be suggested a preliminary plan by which systematic and effective work may be done.

Inasmuch as all the profession will share in the benefits of a closer relation with the public, we assume that the efforts of all should be united on a common ground. More definite plans may be worked out by representatives of leading national engineering organizations at such a time and place as is deemed best. In general we believe that the local society working in coöperation with a central national organization will produce the most satisfactory results.

## DISCUSSION

A. J. Himes in a written discussion stated that publicity should eliminate error from the mind of the layman and of the public concerning engineering and thus clear the way for a proper utilization of the engineer's services. Many people are handicapped in their desire to make use of the wares of the engineer because they cannot talk with him familiarly of the things which they desire to do.

It is a waste of time to deny either the need or the value of advertising. But among professional men the subject is hemmed in with so many restrictions that engineers hesitate to make use of such a method of securing business.

Professional men have always considered it proper to reap the advertising rewards that come from their activities in societies and public affairs. It is doubtless true that a paper of unusual value, because of the information that it contains and the excellent work of its author, is much better as an advertisement than a paper of less merit, with smaller chance of adding to the general knowledge, and which may be presumed to be written chiefly for advertising purposes. It is rather difficult to discover the motives which have prompted a man to go to the trouble of writing and presenting a professional paper and no microscopical examination of such motives is worth the effort.

An important error is made when one concludes that legitimate professional advertising is limited to the writing of a paper.

The profession suffers from certain misconceptions of its patrons, including the public, from among which I will enumerate four as follows:

*First:* It frequently happens on some important work that the preliminary estimate of cost is exceeded in the construction. For this the engineers are roundly denounced. The truth, which never appears in print, is that many such works are completed within the estimate; that where the estimate is exceeded, the cause is frequently a change in plan or increase of quantities for which the engineer has no responsibility whatever; in other cases estimates are stated by men in authority to contain provisions which have not been included; and on some occasions the difficulties encountered are beyond the powers of human foresight.

*Second:* There is frequently an unreasoning demand for the beginning of construction immediately after an appropriation is made without any regard for the necessity of first making surveys and plans. Of this the Panama Canal was a notable example. The evils attendant upon such a course need not be pointed out to engineers.

*Third:* Bombastic and unwise laudation of engineering achievement has developed a popular idea that engineering is mathematically precise. In court and before legislative bodies engineers of prominence are sometimes led to declare their ability to determine by formula and with precision

things concerning which it is only possible to make general deductions. Stresses in rail joints may be cited as an example.

*Fourth:* In the general discussion of the government valuation of railroads, the statement has been frequently made by men in the councils of the nation that the opinion of an engineer is incompetent testimony in valuation proceedings except where it relates to actual quantities which he has measured himself.

It is unnecessary to point out the absurdity and injustice of these misconceptions, and the very great injury which results therefrom to the whole profession. The purpose is to call attention to the necessity for publicity, a publicity that will give to the layman a knowledge of our work.

If the public knew that plans once made are seldom changed without increased expense, it would be demanded of its servants that plans should be made in accordance with the original estimates and then carefully adhered to. It would become important that the first estimate should be right, and that when exceeded the reason therefor should be sound. If it were recognized that some things, as, for instance, rail-joint stresses, were beyond the powers of mathematical analysis, engineers would not be condemned because such stresses have not been figured; or that engineers had followed every step of construction work, from the wielding of a pick and the swinging of a maul to the development of the whole program for the construction of a thousand miles of railroad and the cost accounting therefor, then no judge or statesman could make the public believe that the best results in valuation could be secured without free use of engineering experience.

The public mind can only be disabused of these misconceptions of engineering work and the people be supplied with correct ideas of the possibilities and the limitations of engineering art, by publicity.

The mass of rubbish published every day in the newspapers is an appalling evidence of the paucity of worthy thought among those who cater to a need for information. The country is burdened with the wasteful and wanton exploitation of engineering skill. It is time for the profession to assert itself. Engineering projects of public importance should be passed upon by the engineering societies.

Every medium at the command of the engineer should be used and correct information about engineering work placed before each citizen. The profession should be made familiar to all who have an interest therein, and it is rightful to expect that the increased respect and confidence arising from a more intimate knowledge of such work will greatly enhance its material prosperity.

Coöperative advertising by engineering societies conducted on broad lines for the benefit of the public and so as to put the profession on a more substantial basis, is an aim that is worthy of the highest traditions of this Society.

H. McDonald in a written discussion stated that the engineers of Cleveland were fortunate in having among their number one who in addition to his engineering skill, possesses the taste and willingness to clothe bare technical facts in such garments that they challenge popular attention and interest. If each community were equally fortunate, publicity on engineering matters would be easier.

Few engineers possess this gift or the willingness to devote their time to the task. Many are quite decided in their opinions that there is no need of publicity. They proceed upon the well established theory that virtue is its own reward, and are usually compelled to content themselves therewith.

The writer strongly advocates the participation by engineers in public affairs. They are qualified to guide public policy in matters where their training is of value, but as a class, they have so far failed to convince the public that such is the case.

Their position as a class has been that of an instrument in the hands of other men, who have made a specialty of the study of mankind rather than physics. If engineers can master technical details, they can also learn the laws that control human actions. Recognition is not to be altogether obtained by keeping ourselves and our work before the public in newspaper columns, but by earnest and effective work as organized bodies in every community. That work should consist of watching carefully the manner in which the public affairs involving engineering are administered, taking vigorous organized action looking toward the stopping of the waste of public moneys and graft, and the shaping of legislation involving engineering and industrial matters.

The public should be convinced that we are willing to aid in the proper adjustment of such matters and to give, without selfish motive, sound advice on matters of public policy and the opportunity will not be lacking. A reputation for fearlessness and honesty must be reëstablished and maintained.

Instances are not lacking where professional opinions have been subordinated to the demands of commercialism. Public officers of to-day have difficulty in finding engineers upon whom they can rely for unbiased advice on matters in which organized capital is affected. To merit and obtain confidence engineers must be willing to tell the truth under all circumstances.

It is only such a professional reputation which warrants engineers in making themselves the sole arbiters in preparing specifications, and to preserve that reputation its requirements must be lived up to.

Charles Whiting Baker said that the engineer needs to learn the lesson which is taught by this and Mr. Cooke's paper, of the value of publicity. If the engineer wants to get support for what he is doing, he must know how to reach the ear of the public in the right way. He spoke of the valuable service which had been rendered the street cleaning department by Colonel Waring, who was an engineer. One of his first steps was to put the street cleaning department into white uniforms. The publicity went all over the country and made the department known as it had never been known before and gave the employees a new respect for themselves. This is an instance of what a proper appreciation of publicity may do in a wise engineer's hands.

E. H. Whitlock said that it had been his good fortune to watch the results accomplished in Cleveland by Mr. Drayer during the last two years and that he could heartily commend the work done there. Publicity can be differentiated from advertising. It meets the demand on the part of the public for information as to engineering facts, and who can give this better than the engineer?

Calvin W. Rice thought that it might interest the members of the Society to know that special pains are being taken along publicity lines. Over 60 technical and daily papers in the United States are given copies of everything that we publish and have read at our meetings. In addition special work had been done for this meeting and one of the papers had published over a column in every issue this week.

The Author said that the correct test of publicity was the results obtained. Any plan of publicity must be consecutive, it must continue for a period of time. Enough material has been presented before the Society at this and the session of Wednesday evening to occupy the time of a good publicity man for six months. He must, however, work from the standpoint of the newspaper man. Journalism is a profession; it seeks to give the public knowledge that the public wants. Engineering information must be given to the public on a definite plan, otherwise the newspapers will not give us much attention.

# SNOW REMOVAL

## A REPORT OF THE COMMITTEE ON RESOLUTIONS OF THE SNOW REMOVAL CONFERENCE HELD IN PHILADELPHIA APRIL 16 and 17, 1914.

Early in March 1914, Mr. Morris L. Cooke, Director of the Department of Public Works, Philadelphia, wrote to a number of the leading Eastern cities suggesting the need of a conference on the subject of snow removal and pointed out, that in view of the very apparent lack of engineering methods generally employed in a problem which so clearly calls for engineering study, it might be profitable if those in charge of the matter of snow removal in the larger cities could be brought together, and that at least an approximation of a definite policy of snow removal might result from such a meeting. The suggestion met with such favor that a snow removal conference was held in Philadelphia on April 16 and 17, 1914.

A Committee on Resolutions, J. W. Paxton, chairman, was appointed to submit a report, which would be the result of papers, discussions and recommendations made at this conference, and the Committee makes the following report:

The problem of snow removal must obviously be considered differently in different cities as its solution is dependent upon such variable elements as climate, population, width of streets, density and character of traffic, location of sewer systems, available disposal places and other local conditions, to say nothing of the financial policy of the municipality.

It would seem impossible to formulate anything but the most general suggestions, and yet it is found that even so vital a matter as the financial policy does not affect the main problem, except in the extent of the work.

The work of snow removal is generally done by contract under the supervision of city officials, payment being made according to the quantity removed as tallied by wagons hauling to the disposal dumps, the forces and equipment consisting of men with shovels, horses and wagons. In some cities, scrapers and plows are used to push the snow to the side of the street, relieving traffic and making it easy to pile, or to load without piling.

Salt is generally and very extensively used for the removal of snow in Liverpool, London, Paris and other European cities. The very general practice is to broadcast coarse salt on the streets during and immediately after a snow storm, and when the snow has been reduced to slush by the action of the salt, the streets are flushed with water and the slush washed down the sewers; but in those cities they do not have very heavy snows and it is doubtful whether it would be practicable here where we have a much greater depth of snow. There is also very serious objection to the use of salt by the Societies for Prevention of Cruelty to Animals and in some of the cities it is prohibited by ordinance. It is questionable whether the use of salt has been given a fair trial in this country for the removal of snow and there is little doubt but that it would be useful in light snow storms.

Much thought has been given to the design of apparatus for melting snow and, also, to special machinery for scraping, loading and transporting. Inventors, designers and manufacturers should be encouraged to continue in the endeavor to produce equipment which will render practical and efficient service, but the amount of snow is so variable and the equipment is in use for such a short period of time that it is desirable it be designed to be useful for other work at different seasons of the year.

The problem confronting the public officials is the removal of snow in the shortest time in such a manner as not to interfere with traffic, and at a minimum cost. Therefore, using the method of scraping, shoveling into trucks or carts and hauling to dumps, the length of haul becomes a most important factor and it can readily be seen that the utilization of sewer manholes as dumped, and the sewer system to carry the material to the rivers, is the most economical method which can be devised as it reduces both the haul and the handling to a minimum. The authorities in charge of the sewer systems have, as a general thing, apprehensions regarding the use of the sewer as a snow carrier. The Borough of Manhattan, New York, Bureau of Sewers, however, made experiments during the winter of 1914 which seem to prove that, within certain limits, such apprehensions are ill-founded.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion; price 5 cents to members, 10 cents to non-members.

Gas and chemical combinations in the sewers have little effect on the rate of melting. Two cubic yards per minute is the maximum rate at which snow can be shoveled into a 24-in. manhole. Tidal sewers can only be used to advantage when the tide is low, in which case the factors of the ordinary sewer applies. Siphon sewers can be used as well as the ordinary type.

Where difficulty is experienced with an insufficient flow in the sewers, or where the flow decreases or stops, the water plug may be opened in the drainage area of the sewer above the manhole in use, until the volume of water is sufficient to carry off the snow, but it has been found that the most efficient use of water may be had where water jets are constructed in the manholes into which the snow is dumped. The problem of getting the material into the manholes in the least time with the least interference with traffic opens up a field for the consideration of a special form of manhole to be used satisfactorily for this purpose. Pittsburg and St. Louis both use a special form of manhole.

The Committee gave further an account of the work of snow removal in the cities of Philadelphia, New York, Boston and Scranton, and also of the Public Service Railway of New Jersey, and the Pennsylvania Railroad Company, on which they base the following conclusions:

1st. The plan of organization and the system to be employed should be worked out in advance of the snow season. This preliminary work should involve: (*a*) a plan of coöperation among all branches of the municipal government; (*b*) the formation of a skeleton organization composed of all the available city forces, such as engineers, inspectors, time-keepers, laborers and teams; (*c*) the division of the city into zones and the determination of a definite method of work for each zone. The various members of the organization should be assigned to these zones and the responsible officials familiarized with the duties expected of them.

The character of work to be performed in the different zones may consist merely of the regulation of opening cross-walks and gutters and otherwise generally assisting pedestrian traffic and the run-off of the snow, or it may consist in the complete removal of the snow from the streets. Owing to the general increase in motor traffic and the concentration of business in definite office districts and to the general public demand for increased urban facilities, the present tendency is to increase the scope of the work involving the complete removal of snow from all main thoroughfares and business streets.

2nd. Removal work should commence as soon as the snow has covered the pavements and the indications point to the storm continuing, and should be carried on continuously. This as a principle is successfully followed by street railways and by some cities.

3rd. The carrying capacity of the sewer system should be utilized as far as possible.

The use of the sewers which reduces both the haul and handling to a minimum involves two operations: namely, getting the material to the catch basins or manholes, and then putting the material into the sewers. The first operation can best be done by loading into wagons or trucks and hauling to suitable manholes or by the use of scrapers or graders. The problem of getting the material into the manholes in the least time and with the least interference with traffic opens up a field for consideration of the question of special forms and special locations of manholes designed to be used solely for this purpose.

The method of flushing the snow with fire hose into catch basins may have a limited application but it is too unreliable to have any general value as it depends on weather conditions.

4th. When practicable, where there is only a small area to be cleaned, the work should be performed directly by the municipality by day labor. This method of operation is the most flexible and the most easily administered and it obviates the necessity of measurements and checking involved under the contract system. The work can also be performed by day labor in large areas by adopting the following method: The department to advertise and go out into the open market and hire teams to haul the snow for so much per yard, the price to be determined by the department and to represent a fair estimate of the cost of the work and a fair profit. This, of course, would throw the work open to anyone owning one team, or a hundred or a thousand or more teams, depending upon the amount of work to be performed, and would not leave the department dependent upon any one or more contractors. In this method, as well as when the work must be performed by contract system, a method of measurement as simple and accurate as possible should be used. The practicability of having work done by the municipality will depend among other things on the immediate availability of an appropriation. It is essential for the proper conduct of the work whether by day labor or contract that appropriation for snow removal should be made in advance of necessity for the work.

5th. Coöperation should be sought with the traction companies and use made of adjustable plows and sweepers to open roadways adjacent to street railway tracks at the time that the work of clearing the tracks is being carried on.

6th. Effort should be made to obtain the coöperation of the public and to instruct the householders

in the method of the removal of snow from private premises in such a way as to least impede the city's work. Where sidewalks are of greater width than would be necessary to handle the reduced volume of pedestrian traffic, which may be expected after a heavy snow, the snow instead of being entirely cleared from the sidewalk and piled in the roadway should be left on the sidewalk near the curb line to be later removed by the city when opportunity presents itself.

7th. The police force of the city should coöperate with the street cleaning force and the services of patrolmen as inspectors should be utilized as far as possible. The police in particular should give attention to the enforcement of regulation governing the removal of snow from the sidewalks or from a portion thereof.

## DISCUSSION

J. T. Fetherston,[1] in a written discussion, remarked that New York City has tried almost every method of contracting for snow work, from the area system to the direct haulage method on vehicle capacity basis. Dividing the city into relatively small districts, larger districts and boroughs has been tried, and it would appear that the responsibility and experience of the contractor were of greater importance than the area or district assignments. In other words, an experienced contractor, with the nucleus of the necessary snow removal equipment, as a rule is in better shape to remove snow rapidly and control sub-contractors than is the municipality. More important still, he usually has sufficient control of funds to pay promptly all men employed. It would seem that experience, control of equipment and responsibility are the main factors to be considered, rather than the area basis, for the assignment of contracts.

The statement of general principles contained in the Committee's report would be clarified if the work were separated into these divisions: (1) contract work, (2) street railway assignments, (3) municipal work. Necessarily under each head should be given the plan, and every reasonable contingency covered by the assignment of the most suitable means of snow removal adapted to particular areas, streets or districts of the city under consideration. All municipal departments should be called in to assist the street cleaning division by the assignment of officers for the supervision of contract work particularly, leaving the street cleaning department as free as possible to perform the work for which its own force is best fitted.

As a general comment on the committee report, it is suggested that, if possible, engineers or street cleaning officials should receive from an authoritative source, such as the Society, a summary of conclusions covering:

(1) A statement as to what types of streets should be cleared of snow, and how far the municipality is justified in removing snow from minor thoroughfares at public expense.

(2) A statement setting up the reasonable depth of snow for which a municipality should have equipment available, and in general the time limits within which streets should be cleared, so as to avoid economic loss. Coupled with this, a maximum depth of snowfall beyond which all citizens and transporting agencies should be required to place their services at the disposal of the municipality at cost.

(3) A compilation of snow statistics for various parts of this country, and if possible a summary of attending weather conditions.

Each city must work out its own salvation regarding snow removal and disposal methods. The problem is so complicated by uncertainty as to weather conditions that no particular method is best fitted for all cities and all conditions.

[1] Commissioner, Dept. of Street Cleaning, New York.

E. D. Very[1] in a written discussion pointed out that an endeavor should be made to define the extent to which snow removal should be carried on in a municipality. This definition should not be made in units of mileage or of square yardage but rather in terms of necessity. In this regard the financial policy so affects the main problem as to deserve considerable study, as the extent to which the work shall be carried on depends largely upon the amount of money a municipality can afford to spend. This question must be answered before we may assume that the area to be cleaned has been decided upon and the appropriation of money must be predicated upon an understanding of the actual need in this regard. We should go further and discuss the manner in which funds for the work should be raised. It is suggested that the tax for such purpose should be levied; a part by a general tax and a part by tax on property immediately benefited. Such a method would restrain the indiscriminate demand for unnecessary service for personal benefit.

Whether the work is to be done by contract or by the municipal forces is a question of local condition and must be solved independently by each locality. It is well to remember that where the force engaged in removing accumulations in the street has also the duty of removing the household wastes, the latter item must be considered as of equal importance with the former and the force employed in the latter work must not be reduced by transferring any part of it to the performance of the former. This is especially true when the use of sewers is to be made for the disposition of the snow, as if wastes are not removed they will find their way into the snow bank, and so become a menace in the clogging of the sewers.

For the purpose of supervision, the division of the work into districts is the proper method but to limit a contractor to one district is of questionable value provided the contractor is able to handle more than one district. The fewer contractors on a given area results in less friction, and labor and vehicles are more easily distributed where there is a common interest in the success of the whole work.

Where the work is performed by contract it is well to confine the contractor to the removal of the large accumulations and to employ a municipal force in clearing crosswalks, keeping catch basin inlets open and removing snow from the immediate vicinity of fire hydrants.

If this conference does nothing else but successfully impress the officials in charge of sewers that it is their duty to permit the free use of the sewers for the disposition of snow, it has given ample reason for its existence. Flushing snow into catch basins is not favored as it has not been proven that such work may be practically accomplished without interfering with the necessary use of these devices.

As to the hiring of teams by the city for snow removal,

[1] Sanitary Engr., 17 Battery Place, New York.

it is believed that this is a matter of local condition. New York City has had sad experiences in that line.

As to having an available appropriation for this work, the idea of municipal policy today is to suspect the official of not being worthy of trust in the handling of money, so they limit his appropriation to his actual needs and where the amount which he may need is indeterminate, they hesitate in taking any chance of putting an amount in the hand of the official more than sufficient for his needs for fear that he may spend more than is required.

Police assistance would be most valuable and in the matter of enforcement of sidewalk cleaning regulations the police find themselves very busy but moderately successful. An amendment is suggested that coöperation of police magistrates be employed to the end that police activity may be made effective.

W. Goldsmith[1] called attention to a statement in the report where mention is made of enlarging manholes for the quick disposal of snow. In the Manhattan experiments it was shown that two cubic yards of snow per minute can be shovelled into a 24-in. manhole and that 2560 cubic yards were dumped into one sewer by means of three manholes in an eight hour day. This seems to indicate that a 24-in. manhole is large enough. Besides, the effect of an enlarged manhole on the pavement must be considered, the majority of defects in street surfaces being due to manholes of one nature or another and it seems that the elimination rather than an increase of these enemies to pavements should be striven for.

F. Kingsley pointed out the fact that the same old cart-and-horse methods for snow removal seem to be used that were adopted when the problem became serious some twenty years ago. It is interesting, however, to note the success of the snow-melting device on the Pennsylvania Railroad, because the melting of snow seems to be the most likely path along which improvement can take place.

The cost of fuel to melt snow is only some 15 per cent of cost of handling it under present methods. The basis for this is that a cubic yard of snow as removed weighs approximately 1000 lb. and would require about 200,000 B. t. u. to reduce it to water, allowing a liberal margin over the latent heat of ice. Coal at $4 per ton provides about 67,000 B. t. u. for one cent in a perfect furnace, or 27,000 B. t. u. with 40 per cent furnace efficiency. At the latter rate the fuel cost for melting would only be 7½ cents per cubic yard or 15 per cent of the present apparent cost of handling it. This does not include interest or labor charges but these ought not to be insurmountable obstacles.

The problem is peculiarly one that mechanical engineers should be able to solve. It appears to be largely a balancing of the cost of heating surface against interest charges, and 1 sq. ft. of heating surface can transmit heat (as demonstrated by existing locomotive boilers) at an approximate rate of 20,000 B. t. u. per sq. ft. per hour. With less efficient but more rapid transmission, twice this rate does not seem impossible. On this basis, apparatus capable of melting 100 cubic yards of snow an hour would require 500 sq. ft. of heating surface. Certainly there is nothing abnormal involved in the provision of heating surface in such amounts as this.

[1] Asst. Eng., Dept. of Public Works, New York City.

One hundred cubic yards of compacted snow appears to be equivalent to about 450 cubic yards of snow as it falls, and in a 3-in. snowfall this amount would cover 500 linear feet of street. The subject obviously seems to be one that is worth consideration by the various cities in the country. It would be interesting to see some thoroughgoing experiments along this line.

## THE HANDLING OF SEWAGE SLUDGE

By George S. Webster,[1] Philadelphia, Pa.

Non-Member

Usually the first processes of sewage treatment consist in the removal from the sewage of the solid matter in suspension by means of screens or by sedimentation in tanks or basins. When more refined treatment is required it consists in the oxidation of the liquid portion of the sewage together with the fine suspended matter not susceptible to settlement. This latter phase

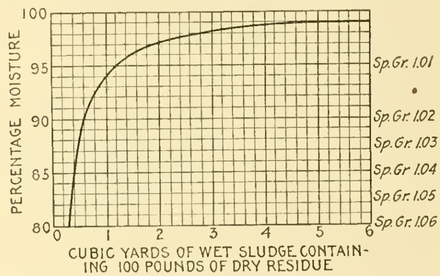



Fig. 1 Rates between Bulk of Wet Sludge and its Percentage Moisture

of the sewage problem will not be considered in this paper.

In sewage treatment, the material collected on the screens and the deposit in the bottom of sedimentation tanks is called sludge. As removed from tanks it is a dark, slimy mass, containing about 90 per cent moisture, and its consistency is such that it cannot be shoveled but can be readily pumped.

Experience with sewage works indicates that upon an average 1000 persons produce 45 tons of dry solid matter per annum. If this were deposited in tanks as sludge containing 90 per cent moisture it would make 524 cu. yd., but if the sludge contained 95 per cent moisture its volume would be 1060 cu. yd., or about double the former amount. In other words, every ton of dry solid matter contained in sludge 90 per cent moisture which is removed, requires 9 tons of water to be conveyed with it, and if the sludge contains 95 per cent moisture, it requires 19 tons of water to be handled.

[1] Ch. Engr., Bureau of Surveys.

Abstract of paper and discussion presented at Annual Meeting, December, 1914. Complete paper may be obtained without discussion; price 5 cents to members; 10 cents to non-members.

One of the most important considerations, therefore, in handling sludge is the percentage moisture which it contains, as this is a controlling factor in its bulk. It is highly desirable to obtain sludge with as low a moisture content as possible (Fig 1).

*Discharges of Wet Sludge in the Sea.* Large cities located near the ocean dispose of the wet sludge most economically by carrying it to sea in specially constructed tank steamers. The sludge is pumped from the sedimentation tanks to reservoirs on the wharf from which the steamers are filled by gravity. When the boat reaches the dumping ground in the open sea the outlet valves are opened and the sludge diffused in the sea water as the boat moves along.

*Depositing Wet Sludge on Land.* For cities situated inland such method of disposal is impracticable on account of the transportation charges and they are confronted with the problem of reducing the bulk of the sludge by removing the water, either by drainage and evaporation on drying beds or by mechanical processes such as presses and centrifuges and of handling it so as to minimize offense.

The type of sedimentation tank adopted, the use of chemical precipitants or the opportunity afforded for sludge digestion have a marked effect upon the volume of sludge produced on account of the moisture content. Generally speaking it may be said that chemical precipitation will produce between 20 and 25 cu. yd. of wet sludge containing about 92 per cent moisture from each million gallons of sewage treated; plain sedimentation from 4 to 7 cu. yd. between 87 and 93 per cent moisture; septic tanks from 1.5 to 3.0 cu. yd. between 80 and 90 per cent moisture; and Emscher or Imhoff tanks from 1 to 2.5 cu. yd. between 75 and 85 per cent moisture.

The disposal of wet sludge without prior dewatering may be accomplished by its application to land in several ways. The earliest method used was called lagooning in which case earth embankments were built enclosing an area of suitable land and the wet sludge run into a depth of as great as 10 ft. The clogging of the soil preventing free drainage of the moisture, the scum formation upon the surface retarding evaporation, and the frequent great depth of the sludge, all tend to prevent the sludge from drying.

To overcome these objections and to dispose of the sludge more quickly, it was run upon the surface of farm land to form a shallow layer which would dry in a reasonable time and could then be plowed in and the field cultivated. But the gross nuisance created by the exposure of such large areas of foul smelling sludge led to the adoption of what is called trenching. As practised at Birmingham, England, the trenches were dug about 3 ft. wide and 18 in. below the surface of the soil, the excavated earth forming banks between the trenches so that they can be filled to a depth of from 24 to 30 in. with wet sludge, after which the tops of the earth banks are thrown over the sludge to prevent nuisance from smell or flies. The porous earth absorbs the moisture and later the land is plowed across the trenches and placed under cultivation. This process can be repeated at intervals of from 18 months to two years.

This method is not being used in new plants and is being abandoned in old plants on account of the area required, the interference which is caused in times of heavy storms, the increased difficulty of operating caused by winter weather and the general cumbersomeness of the method.

*Mechanical Processes for Dewatering Sludge.* Among the early mechanical methods of reducing the bulk of the wet sludge by dewatering was pressing in machines which consist of a number of cast-iron plates generally 9 sq. ft. in area with corrugated faces and surrounded by a machined rim so that when placed together they form water-tight cells 2 in. thick. A central pipe about 6 in. in diameter extends through the middle. Over each plate a canvas cloth is placed and sludge forced into the press and subjected to a pressure of from 60 to 75 lb. per sq. in. This squeezes the water out and the resultant cake contains between 50 and 65 per cent moisture and is about one-fifth the bulk of the original wet sludge.

It is necessary to add to the sludge before pressing from ½ to 1 per cent of lime, the fine particles of which facilitate the passage of water, the dissolved lime agglomerating the solids of the sludge.

Another mechanical method of dewatering sludge is by means of centrifuges which occupy less space than presses and do not require the addition of lime to the sludge. Such machines are continuous in action and the work of extracting the moisture consists of two distinct and constantly repeated periods. During the first period the wet sludge is introduced into the machine and by the action of centrifugal force the moisture content reduced. During the second period the sludge thus partly dried is automatically ejected. The final product contains about 60 per cent moisture and occupies about one-eighth the volume of the wet sludge.

*Digestion of Sludge.* In the methods of sludge handling above described efforts were directed toward preventing the dissemination of the foul odors from the wet mass. Within recent years much thought has been given to devise processes of treatment by the digestion of the putrescent matters to produce an inoffensive sludge both as withdrawn from the tanks and during drying.

One of the methods to accomplish this purpose is to remove the freshly deposited sludge from the sewage sedimentation tanks at intervals and place it in separate tanks. Usually a scum forms upon the surface beneath which more or less active fermentatation and decomposition develops. New sludge is added and digested sludge withdrawn from time to time and placed upon underdrained sand or cinder beds for dry-

ing. On account of the digestion of the sludge it dries more rapidly and is much less offensive than fresh sludge.

For the last 20 years it has been known that the retention of sludge in the tank in which it is deposited, which is known as the septic treatment of sewage, resulted in the reduction of the bulk and offensiveness of the sludge, but experience showed that while the sludge was benefited, the water leaving the tank, known as the effluent, was seriously fouled by the decomposition of the organic matter in the sludge.

The separation of the digesting sludge from the settling sewage was adopted with certain modifications by Dr. Imhoff of Essen, Germany. Two-story tanks of this type are known as Emscher or Imhoff tanks. Their extensive introduction in Germany and America is due to the fact that when properly operated they efficiently free the sewage of its settleable solids, yield a fresh inodorous effluent, produce sludge that is inodorous, of low water content and consequent small bulk.

The principles involved in the construction of the Emscher tanks are shown in Fig. 2. The sewage to be settled flows longitudinally through the tank in the cross-section marked *A;* the solids which settle upon the sloping bottom *B* slide down through the slots *C* into the sludge chamber *D.* The gases of decomposition are prevented from entering the upper chamber by the gas baffle *E* but find free exit through the sides at *F*, in which also a scum forms. A pipe *G* extends from the bottom of the sludge compartment to the outside. A quick opening valve at *H* located at a distance of over 3 ft. below the water surface in the tank permits the discharge of the digested sludge by hydrostatic pressure without any pumping. The sludge is placed upon the drying bed, which is composed of a layer of fine sand supported by a layer of cinders or pebbles and underdrained by the tile.

Dried Emscher sludge is suitable for filling low land or use in agriculture, particularly in lightening heavy soils, as it is very spongy in texture due to the entrained gas. But experience has demonstrated that the use of air-dried sludge from any source will not give results comparable with those obtained from the use of artificial fertilizers.

*Recovery of Ingredients from Sludge.* Sludge contains ammonia, phosphoric acid, potash, grease and carbon. Generally speaking these ingredients are more costly to recover than they are worth. It has been estimated that the manurial value in the excreta of one person in a year is $2.62, but in the dilute sewage of America this would be contained in about 36,000 gal. of water. If this material is deposited as sludge of 90 per cent moisture it would weigh about 1720 lb. per cu. yd., and each cubic yard would contain only about 80 lb. of organic matter, of which only a part has any monetary value.

The problem of recovering the valuable ingredients in sewage sludge, therefore, involves the use of economical and efficient processes for drying or pressing to reduce the bulk for transportation; also in order to recover the grease in sewage with present methods, it is necessary to have the sludge in a very dry condition.

Where refuse disposal plants and sewage treatment works are located in close proximity to each other, an opportunity is offered for the advantageous disposal of sewage sludge by burning it with refuse.

The most serious part of the problem of sewage disposal is the handling of the sludge which results from every known method of treatment. It is possible that in the future, in order to meet higher standards of hygiene and cleanliness, methods may be devised for

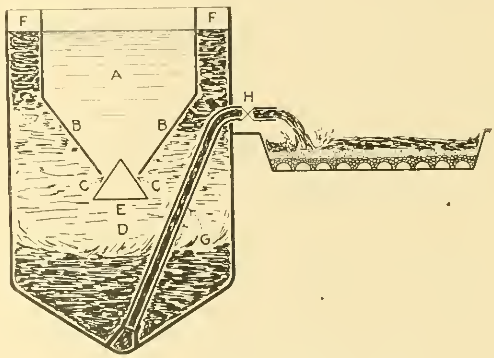



Fig. 2 Construction of Emscher Tank

intercepting sewage solids as near their place of origin as possible, and before they have become offensive, and also to recover practically all of their ingredients which have value prior to their breaking up and in part entering into solution.

This prompt removal of organic matter from sewage will also aid greatly in the prevention of the pollution of the water courses, and will tend to promote the public health and comfort.

In his paper, the author gives data upon several installations in different cities, here and abroad, in addition to the summary of methods of handling sludge which has just been outlined.

## DISCUSSION

C. W. Hendrick,[1] in a discussion of the subject, remarked that the plant at Baltimore is located so that the entire operation is by electricity produced by the flow of the sewage, enabling them to handle the sludge by sludge pumps at a minimum cost. Having this power available, they move the sludge from the separation tank to the digesting tank at frequent intervals before the digestion in the separation tanks becomes a factor.

They deliver the digested sludge at about 90 per cent moisture to their customers by gravity, the wagon driving under

[1] Ch. Engr. Sewerage Commission, Baltimore, Md.

the supply pipe. This reduces the cost of delivery to practically nothing. Where the supply runs ahead of the demand, they pass the liquefied sludge to underdrained sand beds, where it is dried and then sold as fertilizer. In this way they are selling the liquified and dry sludge as rapidly as they are manufacturing it.

About 4 cu. ft. of 90 per cent sludge per person per annum are produced in their separation digestion tanks. In their efforts to produce a market for this sludge, they have tried to meet all the conditions of the demand. Some are taking the sludge at 90 per cent moisture, others wish it in the dry state, and others are considering using it as a commercial filler in fertilizers and require about 15 or 20 per cent moisture. By the use of a centrifugal drying apparatus, known as a direct heat dryer, they have been able to extract the moisture down to about 18 per cent.

W. L. D'OLIER said that the author had so aptly defined the problem in his conclusions that he could not refrain from quoting them: "The most serious part of the problem of sewage disposal is the handling of the sludge." Therefore, this part of the problem of sewage disposal is an important feature in determining the method of treatment. "In order to meet higher standards of hygiene and cleanliness, methods may be devised for intercepting sewage solids as near their place of origin as possible." This is a well expressed thought. Means for such methods are available and are more and more recognized and adopted. He referred to fine screening methods. He agreed with the author that an effort should be made to recover practically all of the ingredients of the sewage solids which have value prior to their breaking up and entering in part into solution, which value is lost with the comminution, disintegration and dissolution of the solids.

In referring to the handling of digested sludge, he stated it is the common practice to select sludge beds, which, at the best, are a local nuisance; the working age limit of these sludge beds before they become impregnated is now recognized as a factor and the care and maintenance of these beds must be of a high order. Further, with the growth of our cities and the necessary increase of sewage, increased area is required and the cost of handling of the sludge onto and off the beds must be considered. In our northern climate, we are also confronted with the abandonment of the use of the beds for a term of months during winter which necessitates the additional cost of providing tank storage capacity.

These facts and features existing with sludge bed practice have urged the mechanical treatment of sludge. The results to date show effective work, but first cost, upkeep, and operating costs have been excessive. A rotary sludge filter developed abroad, now being exploited in this country, promises to lessen costs materially, and represents an important step in mechanical treatment of sludge. The speaker said the values are spent in digested sludge. Sludge from fine screens contains its manurial values and from tests abroad a net return to the plant can be effected by the treatment of sludge for by products.

THE AUTHOR in closing said that whatever process was used in treating sludge or caring for sludge, it should be remembered that a plant is not automatic and it requires constant maintenance at all times on the ground.

# TRAINING FOR CITY EMPLOYES IN THE MUNICIPAL COLLEGES OF GERMANY

BY CLYDE LYNDON KING,[1] PHILADELPHIA, PA.

Non-Member

This paper is the result of a close study of the educational methods of Germany with special reference to the facilities and requirements for training for municipal service. The paper discusses in detail the reasons for the thorough training which is provided, the various groups of schools and colleges available for the work, the curricula which are followed, and the methods and character of the training. There is a brief review of the facilities in our own country for such instruction and comparison is made of their work with the work accomplished in Germany. In what follows, a summary is given only of certain sections of the paper and the reader is further referred to the complete pamphlet.

Four factors may be singled out as being responsible for the tendency toward sustained and thorough, yet specialized and practical, preparation for municipal service in Germany.

The first is the rapid rise in urban populations. Half of the German population are now urban residents. This enormous increase in urban populations means an increase in public functions assumed by city governments many times greater than the increase in population and requires efficiency and training of public employes.

Preparation for governmental positions in the state has been provided for in the state universities. These institutions are under the domination of practically the same group of officials that control the state administration. Thus, while state positions are amply prepared for, at least in certain of the universities, they do not tend to give the specialization and the emphasis upon municipal service demanded by urban needs, and a demand was created for local institutions that would offer the necessary training for municipal employes. This constitutes the second factor.

The burgomeister and the paid expert advisers in the magistrat were, as a rule, well trained at the state institutions. But no special training was provided for the great rank and file of city employes, the efficiency of whom, after all, decides the skill and utility with which the taxpayer's money is spent. The need for training well every municipal employe through inadequate preparation for positions, is the third factor.

The fourth factor is that public service is a recognized profession of dignity and permanence in tenure. The oft-repeated assertion that there is *no* politics in

[1] Wharton School of Finance and Commerce, Univ. of Pa.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion; price 5 cents to members, 10 cents to non-members.

German city positions is far from accurate; but in Germany the provincialism characteristic of so many American cities, which brands experts from other cities or states as " outsiders " or " aliens," finds no place. The result is that a public employe with adequate qualifications, who finds himself blocked in one city because of his party affiliations, can look toward employment in other cities. A position once secured, a tenure for life or for a term of 12 or 24 years, is assured, followed by a pension at the end of service. Moreover, promotion is made from city to city so that there is no limit to the economic returns and social prestige of the public official of competence and skill. Even the burgomeister and all the leading expert advisers in the magistrat are chosen at will from other cities. The salary, moreover, is adequate to attract the best talent, and increases in remuneration follow at specific intervals. The national laws frequently provide that appointees to certain positions shall have stated professional qualifications, but all examinations are qualifying and not competitive. The result is freedom of choice by an employing official who must have the best talent and get the best results within his expenditures, for pressure of the tax is as keenly felt in German cities as in American cities.

The fifth factor is the fact that the great public utilities such as the street railways, gas and rail waterways, are publicly owned and operated. This means that not only the best paying positions but also the positions carrying with them social prestige and honor, are within the gift of the state rather than in the power of private corporations. The youth of capacity and training turns, therefore, by preference to the public service.

The technical training required for the municipal expert in Germany is usually afforded by some branch of the regular educational system.

In the great technical universities everywhere maintained by the individual states, technical training of the most definite and specific kind can be obtained for either public or private expert work. At the present time there are 11 great scientific universities, the organization of which is under the control of the several states of the German empire.

Below the highest technical institutions are two grades of machine trade or mechanical engineering schools, those providing for the training of engineers, constructors, foremen, machine draftsmen, etc., and those of a lower grade which train machinists, mechanical draftsmen and technical officials of middle rank and others preparing for positions that require a less highly developed technical ability. To both these classes of schools are often added Sunday and evening courses, open to workmen who cannot afford to give up work entirely and attend school.

Technical preparation for expert work in building trades can be secured in the fifty odd building-trades schools in Germany, most of them with two departments; architectural (Hochbau) and civil engineering (Tiefbau).

Technical preparation for the industrial arts can be secured in either one of the following groups of art trade schools: industrial continuation schools for the art classes; schools for hand-crafts; schools for industrial art and hand-crafts, and industrial art schools. Preparation for other special positions requiring technical preparation can be found in the continuation schools, in the textile schools, in the technical schools for woodworkers, in the commercial schools, many of which are also supported by the leading commercial and labor organizations of the country, in the modest classes conducted in winter evening hours by the light of the oil lamp in the low school room of the villages.

General school training, however, can not make the efficient employe; for this there must be scientific preparation and, in the case of employes and officials in municipal service, particular training. The author takes up a study of the general educational system for municipal employes, with a discussion of partienlar institutions, based on an extensive study of catalogues and announcements. Two examples only will be quoted in this abstract, the Akademie für kommunale Verwaltung zu Düsseldorf, and the Erste Preussische Verwaltungs-Seminar zu Aschersleben.

The purpose of the academy for municipal administration in Düsseldorf, opened for work in the autumn of 1911, is to strengthen and broaden the knowledge of and to offer a scientific and practical training to municipal officials, and to give business-like, scientific and practical education to persons intending to enter the municipal service. A survey of the courses offered and the methods employed indicates that the academy is primarily an institution for the further training of the higher municipal officials.

The academy is a municipal institution of the city of Düsseldorf, established by the city council. The teaching staff is composed of (*a*) official expert teachers. (*b*) expert teachers who offer lectures for each academic year, (*c*) honorary experts, who offer lectures for a specified time on unspecified subjects, (*d*) leading state and municipal officials, (*e*) scholars and (*f*) former professional men who are procured for certain discourses. While the academy is thus under municipal control and supported by municipal grants, it is subject to state supervision by the minister of ecclesiastical and educational affairs.

The courses offered include the following subjects: Constitutional rights; governmental rights; the police power; social questions; school and sanitary administration and legislation; insurance law; road law; economics; agricultural economy; political science; sociology; the resources of the country; national economy; the lawful rights of government; the organization of city, state and nation; efficiency in government; the science of finance; taxation law; money and bank-

ing; public works; the city's utilities; statistics; building regulations and administration; the cultivation of prosperity and of refinement; defense of the country; the labor question; relief of the poor; business law; practical work in administrative law; municipal finance and constitutional law; criminal law and procedure; the poor law; administrative law; labor union laws and their interpretation; criminology, hygiene and commercial and financial bookkeeping.

Selective courses are provided, such as one in the science of law which includes the foundation principles as to the rights of citizens and the rights of officials; purchases, leases, deeds and their characteristics; indemnity obligations of the community; earnings and laws of properties; real estate law, rights of mortgages, the authority of parents and the power of the respective governments as guardians; the rights of associations and of business; commercial law; the foundation principles as to state, rural and city administrative law; the constitution of the state of Prussia, the Imperial constitution, the rights of administrative organs of government, the police power and the general position of the police including the safety and sanitary police. There is a course in taxation, one in insurance law, statistics. Thorough-going courses are offered in national economy with special application to the protection of properties and the development of new industrial opportunities. Corrupt practices and efficiency in government are likewise taught as are the cultivation of prosperity in the different communities and the inculcation of the proper doctrines as to a national program for industrial supremacy. In the course germane to pure water for the city are given complete geological data.

Quite in contrast to the Düsseldorf academy, which trains primarily the higher officials, is the Professional Training School for Civil Service at Aschersleben which offers courses preparing primarily for the one year probationary service the middle and lower classes of public employes, and for promotion from a lower to a higher grade of service. The institution is administered by the magistrat of the city of Aschersleben and its stated purpose is "to give to young persons the general and professional education necessary to enter the public service career as a minor or middle officer." The course gives at the same time an opportunity to prepare for higher municipal adminstrative positions, such as mayors in smaller towns and the higher posts in the larger towns.

The duration of the general course is three years. The school also offers a one year special course for the training of minor civil service employes under governmental, provincial and administrative boards, as well as a one year continuation training course for minor municipal officials. It also provides a three months' continuation course for those in military service who may desire to prepare during compulsory army service for minor governmental positions.

The curriculum includes three general classes of subjects: (*a*) scientific courses such as German, mathematics, history, geography, French, English, chemistry and physics; (*b*) professional courses such as jurisprudence or general legal knowledge, constitutional and administrative law, social administration, political economy, public finances, the science of taxation, the budget and the treasury; and (*c*) applied courses such as typewriting, stenography, drawing, accounting, bookkeeping, arithmetic and German.

The instructors are employed teachers and the public officials of the city of Aschersleben. At the end of the one year, the tuition for which is 150 M., there is a final examination in the presence of a state examiner, the chief burgomeister of Aschersleben and invited members of the Central Alliance of Prussian officials on the basis of which a final graduation certificate is given.

This survey of what certain German institutions are doing leads to these definite conclusions: (*a*) While American universities are doing much, they are not offering the practical, definite preparation for public service that is being offered by certain German institutions; (*b*) that the courses of study offered and the plans for municipal colleges in Germany point to endless possibilities for adaptation in the courses and work being offered in American colleges and universities; (*c*) to the end that the public employe may be more adequately and efficiently trained, our colleges and universities can extend with profit to themselves and to the public, the number of definite, practical courses offered in their institutions; and (*d*) particular attention can and should be given to the preparation for special types of public service in certain of our educational institutions. One or two of the universities in the larger cities can prepare definitely for municipal service, others for the consular and diplomatic service, others for state service, others for service in departments of health and sanitation, while others can prepare experts in engineering, social, financial and accounting fields; and (*e*) there is a need in America for a few special institutions offering a specialized training of and for the public employee, who has had his technical preparation such as is given in the Academy for Public Administration at Düsseldorf and the Seminary for the Public Service at Aschersleben.

## DISCUSSION

J. F. Young,[1] in a written discussion, questioned whether courses in municipal subjects should be offered chiefly for the young college student or for the city employe. Hereto-

[1] Univ. of Penn., Phila.

fore we have taken for granted that the young college man was to be the source of our future supply of city experts.

We should work chiefly in the opposite direction, and should so arrange our courses that they will appeal to and help the man who is already active in city employment, or the practising engineer, who after having seen the problem from a point nearer its center, has decided that he wishes to devote himself to city work. Both these types of men are far more valuable for the purpose of providing and training an adequate supply of scientific technical city administrators and experts than the young college student.

A sharper distinction is needed between the general course on city government and the technical highly specialized course on sanitation, housing conditions and methods, city transit, labor, accounting, finance, etc. Thus far we have tried to cover all these fields and have therefore presented in a single course a group of studies which are too general for the technical student and too technical for the general student.

With the new attention to the subject which is now arising, we must have a clearer notion of the class of men and women who are to be trained; a relegation of the general courses to the field of general education of college undergraduates; and a more extensive development of the highly specialized technical subjects for smaller classes of professional men and women. This plan also involves a complete transfer of the technical work to the evening, in order that it may be pursued by those who are already engaged in engineering, municipal employment or other vocations.

Such a sharp distinction between courses, based on a clearer view of the clientele to which they are to appeal, would lead to a different development from that in Germany, but would answer more fully the distinctively American needs for the training of municipal servants.

J. A. Fairlie,[1] in a written discussion, stated that the professional schools in this country, in the state and private universities, are giving professional training in engineering, law and medicine, which offers special training for municipal service. In several states there are Associations of Municipal Officials which hold their meetings and carry on their work in coöperation with the state universities. It has been suggested that the university should offer a series of short courses, for a week or two, in municipal subjects, for city officials, similar to its short courses in agriculture.

There is undoubtedly need for further development. This will require the active coöperation of our educational institutions, public officials and the members of the several technical professions.

H. S. Gilbertson[2] wrote that there is an academic and practical reason why we have not developed a profession of public service. The academic reason is that there has been a fear on the part of a large number of political leaders that democracy would be endangered by a permanent and highly trained civil service; that we would drift into bureaucracy, and all that it entails. The practical reason is that another, and a very large element in political leadership, has desired to control appointments to public office for party reasons.

So long as this latter condition prevails, it is perfectly obvious that mere efficiency and fitness are minor considerations, and public service was repellent to men of high qualifications.

Present conditions afford much hope that both the academic and the practical objections to a trained civil service will gradually disappear.

Civil service reform also obviously favors the trained men. The merit system in the civil service was primarily devised as a method of eliminating politics and the most unfit applicants for public office in the lower grades of the service. But civil service reform is developing in new directions and is correcting some of its mistakes. There is a tendency to make records of efficiency the basis of promotion. This undoubtedly will favor not only a higher degree of preparation on the individual's entry into public service, but a certain standard of performance will be made the price of his remaining in the service. This should so dignify civil service that a higher type of men will be attracted to it.

Still another movement which will greatly favor a trained body of public servants is the application of the principle of the short ballot. When it is carried to its logical limits there will be a much sharper distinction made in the public mind between politics and administration.

There is coming to be a general recognition on the part of all intelligent people of the need for better trained public officials. People are beginning to see that when everything else is being subjected to high efficiency tests, government cannot much longer be run on the haphazard plan which has obtained in the past. Also there is the high cost of government. It is impossible to tell what we are paying for unnecessary and ill-performed public service. Senator Aldridge, some years ago, made the statement that $300,000,000 a year could be saved by the federal government.

Finally, we must consider the growing complexity of governmental functions. It is not simply that we are branching out in new fields, but that we are undertaking in a scientific way to perform old obligations. Police administration, for example, has become almost a science. In the field of corrections we are not content to have jail keepers, but we must have constructive sociologists who know something about the causes and remedies of crime. Likewise, public health administration no longer means stamping out epidemics, but it seeks to eliminate the conditions which may at any moment produce ill health.

Sanford E. Thompson said that in the problem of municipal work we must also consider the demand for municipally trained men. Until our cities realize the necessity for these men and there are more openings for them, there will be very little increase in the education to be offered. This situation, however, is improving, through the appointment of city managers and other steps tending toward the department of municipal work. He believed that the college alone does not offer the training that it should for this kind of work. The student must also have practical experience, and he had found the best men to employ to be those who have done practical work, worked their way through college or done special work in the summer.

[1] Univ. of Ill., Urbana, Ill.

[2] Exec. Secy., The Natl. Short Ballot Organization.

# A STUDY OF CLEANING FILTER SANDS WITH NO OPPORTUNITY FOR BONUS PAYMENTS

BY SANFORD E. THOMPSON, NEWTON HIGHLANDS, MASS.

Member of the Society

Efficiency in municipal government will come about only as the work in the various departments is put on a basis which gives each man, from the common laborer up to the skilled artisan and clerk, a well-defined task to do in a given time, with a definite reward for its accomplishment. Under the ordinary methods of handling city work it is cheaper where there is fair competition to let work by contract than to handle it by day labor. With an effective system that eliminates not merely favoritism but also presents a definite incentive for each man to do a fair day's work, a city may save the contractor's profit, employ its own force of city men, and avoid one of the largest sources for mulching a city treasury through collusion between the city officials and contractors.

The construction and maintenance work in the department of public works is a field that offers the largest opportunities from an engineering standpoint. It includes such operations as trenching, pipe-laying, sewer construction, aqueduct construction, filter cleaning, street cleaning, road building, grading, concrete work, and building construction. All of these can be handled by scientific methods.

In the present paper one of the accomplishments of the City of Philadelphia along the line of improved methods is described, viz., the cleaning of filter sand, one of the operations in the Bureau of Water of the Department of Public Works, which is in charge of Mr. Carleton E. Davis, Chief of the Bureau, and under the supervision of Mr. Morris L. Cooke, Director of Public Works.

*Results Accomplished.* The object of the plan has been to lay out the work of each gang of men so as to increase the effectiveness of the plant and provide a definite task to be accomplished in a day.

The results of the plan which is being put into operation are as follows:

Rotation of cleaning the filters is planned in advance by well defined rule.

A definite area of sand to clean is assigned to each gang, this area depending upon the depth of cleaning necessary.

This setting of tasks has increased output of each gang 15 per cent and this should be further increased to at least 25 per cent.

Abstract of paper and discussion presented at the Annual Meeting, December, 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

Accurate records are kept, showing the time consumed by each gang.

Cost accounts, as well as pay-roll, are made up from the time tickets furnished to the men.

Gang leaders are required to pay closer attention to their duties.

Improved apparatus and machinery are under consideration.

Methods of determining depths of sand to clean are being standardized.

*Obstacles Encountered.* The paper contains an account of the methods introduced to secure these results. As indicated in the title of the paper the Philadelphia ordinances prevent the payment of a bonus and thus make it difficult to encourage the men to accomplish the tasks assigned to them. The city fixes the rate of pay of unskilled laborers on a level wage per day regardless of the quality of the workman or the amount of work he can do. Civil service regulation, which prevents the discharge of a man for political reasons, also limits the power of discharge for inefficiency. Although the fear of discharge affords a crude means for obtaining a fair day's work, its elimination, with no opportunity for providing a substitute increases the difficulties. The handling of the work would have been much simplified if it had been possible to provide, for a man well fitted to his work, a reward for accomplishing a good day's task.

At the beginning, the general attitude of the men and the foremen was antagonistic, as is almost always the case where new methods are being introduced. This is gradually overcome as the results become evident.

*Method of Attack.* The method of attacking any problem in order to place it on a scientific basis varies with the character of the work. In certain cases, such as intricate factory operations, it is necessary, before any tasks are set or even before time studies are made, to establish a complete system of routing the materials and the employes. In other cases the first necessity is to establish standards, making minute investigation of the processes. In still other cases time studies can be made at the start.

In the sand cleaning proposition all of these methods were carried on in a measure simultaneously. Studies were made of the men and the methods employed to see where the manner of handling the work could be improved. Time studies were made to determine the unit times for each individual operation, so that the tasks could be figured accurately in advance. From records already on file, giving the approximate time for cleaning, it was possible to begin the organization of the routing system.

*Unit Times.* The unit times for the individual operations were determined by the taking of a large number of time studies in such a way as to eliminate all unnecessary delays, but with a sufficient allowance

for resting and delays which were unavoidable. The unit times obtained are given in Table 1.

TABLE I UNIT TIMES

| Operation | Unit Time per Operation Min. | Time per Cu.-Yd. per 1-in. Depth Min. |
|---|---|---|
| Moving hopper | 0.20 | 0.34 |
| Moving separator | 0.50 | 0 45 |
| Moving hopper hose | 0.25 | 0.11 |
| Moving track | 0.83 | 0.44 |
| Waiting for hopper to empty | 0.42 | 0 38 |
| Moving pressure hose | 1.80 | 0.36 |
| Additional necessary rest | .... | 0.12 |
| Shoveling to hopper | .... | 6.32 |

The time given in each case is that for the gang, since it was necessary on this work to set a task for the entire gang instead of starting the individual men, as it is always best to do when possible. The time of shoveling into the hopper is in each case based on the rate of output that the ejectors will take care of. It was found that one man, instead of two, could very nearly produce the required output, but this would have lengthened the time of cleaning so as to be inadvisable. For example, with one man shoveling, the shoveling time per cu. yd. is 8.8 minutes with a 1-in. depth, and 6.75 minutes per cu. yd. when the depth is 18 in. These studies indicate therefore that further change is necessary in the method of operation so as to increase the output of the injector and separator in order to obtain the full value of the labor of the gang.

*Routing.* The routing was accomplished by the aid of a bulletin board of the type used in the Taylor system provided with suitable hooks for the tickets which designated the work of each man. One of the lines of books held tickets indicating "Work to be done NOT READY"; a second line above it, "Work to be done READY"; and the third line, above this "WORK IN PROGRESS." On these tickets, there is space for all the information required.

*Setting Tasks.* Having determined the unit times and established the system of routing and giving out of tickets, the area of surface that should be shoveled by each gang was figured and the point to which they were supposed to go in a day's work was marked with a flag. Curves have been plotted, giving distances to clean for the outside and inside gangs for various depths.

On the first two days, after everything was ready, no instructions were given the gang leader or the men as to how much they were expected to do. The total area shoveled by each gang, however, was noted, and compared with the area they should have accomplished. Every gang shoveled less than the figured area, the amount running from 10½ per cent less to 31½ per cent less. After this second day's work we concentrated on one gang, and laid out in advance the amount they should accomplish in a day. As a result, they readily accomplished the task and reached the mark. The task setting was then extended to other gangs.

An interesting point came up in connection with the handling of the work at first. The men in the outside bays had to shovel about 7 per cent more sand than those in the inside bays because the areas were wider; nevertheless, all gangs had been accustomed to keep abreast, the men who had the narrower width to handle slowing up to accommodate their speed to the outside men. When the men began working by the task, the inside men, because of the narrower width, were given the longer area to cover and gaged their speed to accomplish their task. The outside men, although shoveling a greater width kept abreast with them without special trouble, thus exceeding their task.

## DISCUSSION

Carleton E. Davis[1] contributed a discussion in which was additional information upon the operation of the Philadelphia filters. A few quotations follow:

The labor cost of operating the filters of the Philadelphia water supply is about $175,000 per year. The result of Mr. Thompson's work as maintained up to the present time is to increase by about 15 per cent the output of the force employed upon cleaning sand in the final filters. This phase of the filter operation represents perhaps 90 per cent of the total labor cost of running the plants. This pick-up is very gratifying to all concerned and the author may well feel pleased that he has accomplished so much in the face of adverse circumstances.

Mr. Thompson's studies have developed a marked advance in the organization of the force and the handling of problems connected therewith. They have not, however, changed the fundamental characteristics of the filtration factors of the plant, nor have any new underlying principles been discovered. This should be clearly understood and the statement that rotation of cleaning filters is planned in advance by a well defined rule should be interpreted accordingly. The planning is done in advance as far as possible, as is the case in all well organized filter plants, but no new rule has been discovered or developed whereby each filter can be assigned to a fixed position in a prearranged cleaning schedule.

The Delaware River from which the Torresdale filters take their water is affected by storms and other weather conditions, by seasonal changes, by temperature variations, by tides, and even by navigation in the stream. A sudden or unexpected storm or any one of a number of other phenomena may upset any prediction as to the exact day when a particular filter should be cleaned.

The sand cleaning groups are now working at increased speed and with less lost time caused by errors or false motions on the part of the foremen. Certain factors stand out more prominently than others in having produced these results. Defining in advance what shall constitute a day's work, clear and easily understood general orders, and the toning up of the organization whereby each man is more

[1] Chief Bureau of Water, Philadelphia.

or less on his mettle, appear to be the features productive of the most good.

Time studies were instrumental in determining what is a fair day's work. Experience showed that better results were obtained by clearly marking the limits of each hour's work rather than depending upon a single mark defining the end of a whole day's work. The more frequent goals aid the judgment of the foremen and stimulate the efforts of the men.

General standing orders containing explicit and readily interpreted instructions about each feature of the work are issued to all foremen. These orders place before each man an outline of his duties and take away the excuse of ignorance or misunderstanding.

The Author in closing said that he did not agree with Mr. Davis in his idea that the arrangement of the cleaning cannot be designated very distinctly in advance. Studies have been made to a certain extent on the general operation of filters at different plants, with a view of going into this matter but a continuation of study in this line is bound to result in a possibility of planning the different features very definitely and reaching the fundamental conditions which do not appear on the surface.

# THE DESIGN AND OPERATION OF THE CLEVELAND MUNICIPAL ELECTRIC LIGHT PLANT

By FREDERICK W. BALLARD, CLEVELAND, O.

Member of the Society

The new municipal lighting station on East 53rd street, Cleveland, Ohio, went into operation July 20, 1914. It is the largest central station to be built by a municipality in this country, and is intended not only to supply electric current for street and commercial lighting, but also for power users. The rates which are being charged for service range from $0.03 per kw-hr. maximum to $0.01 per kw-hr. minimum. This station has a capacity of 25,000 kw. and is at present loaded to one-fifth of its capacity.

The decision to build this plant by the city of Cleveland was the result of experience with a small station of 1500-kw. capacity, known as the Brooklyn Station, which has been in operation by the city since 1906. It had been started by a bond issue of $30,000 and had by appropriations amounting in all to $211,649.22, together with additions to its plant from profits and earnings, grown to a total investment in plant value of $548,182.43. It had thus made the remarkable record of having acquired more than one-half of its total value in eight years from the earnings of the plant itself. Table 1 is a condensed statement of the financial record and Tables 2, 3 and 4 of the revenue and expense from this station.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to non-members.

TABLE 1 PLANT VALUE OF BROOKLYN STATION AND DISTRIBUTION SYSTEM

| | | |
|---|---|---|
| Bond issue 1902 | | $30,000.00 |
| From taxes and general fund | $320,796.24 | |
| Value of street lighting | 109,147.02 | |
| Added to plant value from taxes and general fund 1906–1909 | | 211,649.22 |
| Added from earnings | | 306,533.21 |
| Investment in Plant, Dec. 31 1913 | | 548,182,43 |
| Depreciation written off Dec. 31, 1913 | | 113,244.19 |
| Depreciated Value of Station Dec. 31, | | $434,938.24 |

TABLE 2 REVENUE AND EXPENSE STATEMENT FOR YEAR 1913

| | | |
|---|---|---|
| Total revenue from sale of current | | $185,698.81 |
| Kw-hr. generated.... 7,797,661 | Average sale price.$0.0238 | |
| Kw-hr. sold. 5,656,668 | Average sale price. 0.0328 | |
| Total operation and maintenance expense | | 116,719.55 |
| Kw-hr. generated.... 7,797,661 | Average cost price.$0.0149 | |
| Kw-hr. sold. 5,656,668 | Average cost price. 0.0206 | |
| Net earnings | | 68,979.26 |
| Fixed charges—depreciation and interest | | 19,079.50 |
| Kw-hr. generated.... 7,797,661 | Average cost price.$0.0024 | |
| Kw-hr. sold. 5,656,668 | Average cost price. 0.0033 | |
| Profit for year of 1913 | | $49,899.76 |

TABLE 3 POWER STATION REPORT FOR YEAR 1913

| Operation | | Unit Cost |
|---|---|---|
| Labor | $23,050.25 | $0.0029 |
| Oil, packing and waste | 1,538.52 | |
| Water | 3,110.00 | |
| Sundry expense | 743.32 | 0.0007 |
| Coal | 39,275.42 | 0.005 |
| Maintenance | | |
| Buildings | $105.85 | |
| Boilers | 3,515.98 | |
| Engines and generators | 3,449.72 | |
| Condensors and piping | 606.91 | |
| Switchboard | 153.48 | |
| Tools | 223.81 | |
| Arc light equipment | 661.88 | |
| Sundry repairs | 246.21 | 0.0011 |
| Total operation and maintenance | $76,681.35 | 0.0097 |
| Total kw-hr. generated | 7,797,661 | |

TABLE 4 DISTRIBUTION SYSTEM—OPERATION AND MAINTENANCE FOR YEARS 1912–1913

| | 1912 | 1913 |
|---|---|---|
| Poles and lines | $7,342.53 | $8,203.32 |
| Arc lamps | 2,241.68 | 4,485.53 |
| Meters | 334.12 | 486.68 |
| Tools | 197.25 | 213.69 |
| Wagons, harness, etc. | 582.16 | 760.28 |
| Stable expense, feed, etc. | 1,134.86 | 1,935.57 |
| Carbons and globes | 2,219.08 | 2,735.80 |
| Trimming labor | 2,811.25 | 2,437.48 |
| Services, transformers, etc | 3,224.87 | 6,166.62 |
| Miscellaneous expense | 573.40 | 1,084.94 |
| Auto truck | ...... | 923.61 |
| Substation maintenance | ...... | 2,054.98 |
| | $20,661.20 | $31,846.50 |
| Kw-hr. generated | 4,611,853 | 7,797,661 |
| Cost per kw-hr. generated | $0.00448 | $0.00408 |

A close analysis of the figures in the tables shows that in many cases these costs could be greatly reduced by the operation of a system on a large scale, and by the efficiencies which will be obtained in the new power station. The item of cost in central station work which has usually been considered the most uncertain and problematical, and therefore most likely to stand in the way of success for manicipalities, is the cost of distribution. The costs for operation and maintenance of the distribution system connected with the Brooklyn Lighting Station in Cleveland, becomes, therefore, of particular interest, and the itemized costs set forth in Table 4 establishes a certain definite value for this feature.

PRELIMINARY ESTIMATES FOR THE NEW STATION

The estimated results which will be secured from the new 25,000-kw. station which has just been placed in operation, are based upon an annual output of 60,000,000 kw-hr., and with fixed charges based upon a total plant investment of $3,000,000.00. Fixed charges amounting to 9 per cent on this investment would equal $0.0045 per kw-hr. Cost for coal is estimated at $0.002 per kw-hr. Station costs exclusive of coal at $0.0015. Distribution costs, exclusive of fixed charges at $0.004. Administration charges at $0.0005 and profits at 8 per cent on the investment at $0.004. This makes an average price to be secured per kw-hr. generated of $0.0165. From the three months' operation of this station, together with tests that have been conducted the indications are that these estimated results will be secured.

In explanation of these figures, the author says that it would be conservative to allow for an average interest rate of 4½ per cent on the whole investment of $3,000,000. The tax rate can be conservatively estimated at 1½ per cent, and the rate to be allowed for a reserve fund for depreciation, or what really would better be known as an amortization fund, since depreciation, obsolescence, etc., will be taken care of from the maintenance fund. The amortization fund should be taken care of by a rate of 3 per cent, this rate for use as a conservative allowance, because 2.92 per cent of the original cost invested annually at 4 per cent compound interest will equal the original investment in 22 years. These rates for interest, taxes and depreciation call for an annual allowance to cover fixed charges of 9 per cent of the original investment.

In order to arrive at the estimated unit cost for the fixed charges, it was necessary to assume a certain total output for the station for a year. A 40 per cent load factor is generally considered very good in central station work. There is no question, however, but that under good conditions a load factor much better than this can be secured. Assuming a 40 per cent load factor in a peak load of 18,000 kw. would give a total output a year of approximately 60,000,000 kw-hr. Fixed charges for the entire plant investment of $3,000,000 rated at 9 per cent would amount to $270,000 per year, and on the basis of a 60,000,000 kw-hr. output the cost per kw-hr. to cover fixed charges would be $0.0045 or $0.0015 for the station cost and $0.003 for the distribution cost.

Other items to be decided upon are unit costs for coal, labor, maintenance and sundries; expense for operation and maintenance of the distribution system; and administration charges. The value of

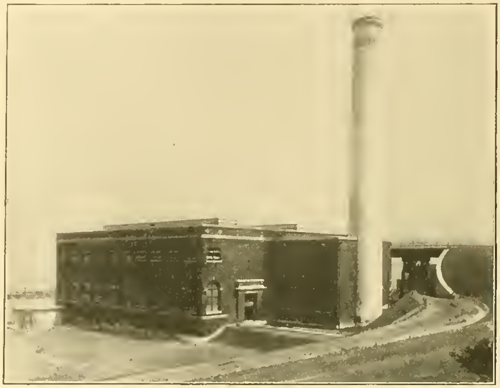


Fig. 1 Exterior View of the Cleveland Municipal Lighting Plant

$0.0005 for the last item was based on the known cost in connection with the Brooklyn Station. In order to be fair in making a comparison with privately owned and operated plants, an allowance was made for profit of 8 per cent, or $0.004 per kw-hr., as mentioned above. The several unit costs are given in Table 5.

TABLE 5 ESTIMATE ON UNIT COSTS FOR EAST 53RD STREET STATION

| Station Costs | Cost per kw-hr. |
|---|---|
| Coal | $0.002 |
| Labor, maintenence and sundries | 0.0015 |
| Fixed charges | 0.0015 |
| Total station costs | 0.005 |
| Distribution Costs | |
| Operation and maintenance | 0.004 |
| Fixed charges | 0.003 |
| Total distribution costs | 0.007 |
| Administration Charges | |
| Administration charges | 0.0005 |
| Total amount cost | 0.0125 |
| Profit required | 0.004 |
| Average sale price required per kw-hr. generated | 0.0165 |
| Estimated kw-hr. to be generated | 60,000,000 |

### RESULTS OBTAINED

The results which have already been obtained in the operation of the Brooklyn Lighting station and the East 53rd Street station during the first eight months of the year 1914, tend to substantiate the original estimates of what will eventually be secured in connection with the operation of the East 53rd Street station. Following is the statement of revenue and expense connected with the operation of these two stations for the first eight months of this year:

REVENUE AND EXPENSE STATEMENT FOR FIRST EIGHT MONTHS 1914

| | | |
|---|---|---|
| Revenue from sale of current for first 8 months of 1914. | | $153,363.65 |
| Kw-hr. generated.... 7,863,610 | Average sale price. $0.0195 | |
| Kw-hr. sold. 6,270,726 | Average sale price. 0.0244 | |
| Operating and maintenance for first 8 months... | | $97,044.60 |
| Kw-hr. generated.... 7,863,610 | Average cost price. $0.0123 | |
| Kw-hr. sold. 6,270,726 | Average cost price. 0.0154 | |
| Net earnings for 8 months........................ | | $56,319.05 |

The total kw-hr. generated for eight months is greater than the output for the entire year of 1913. The average cost price per kw-hr. generated is $0.0123 as compared with $0.0149 for the previous year.

The East 53rd Street station has been in operation since July 20, 1914. The results secured in the way of operation and maintenance costs in the power station itself for the month of August and September are shown in Table 5.

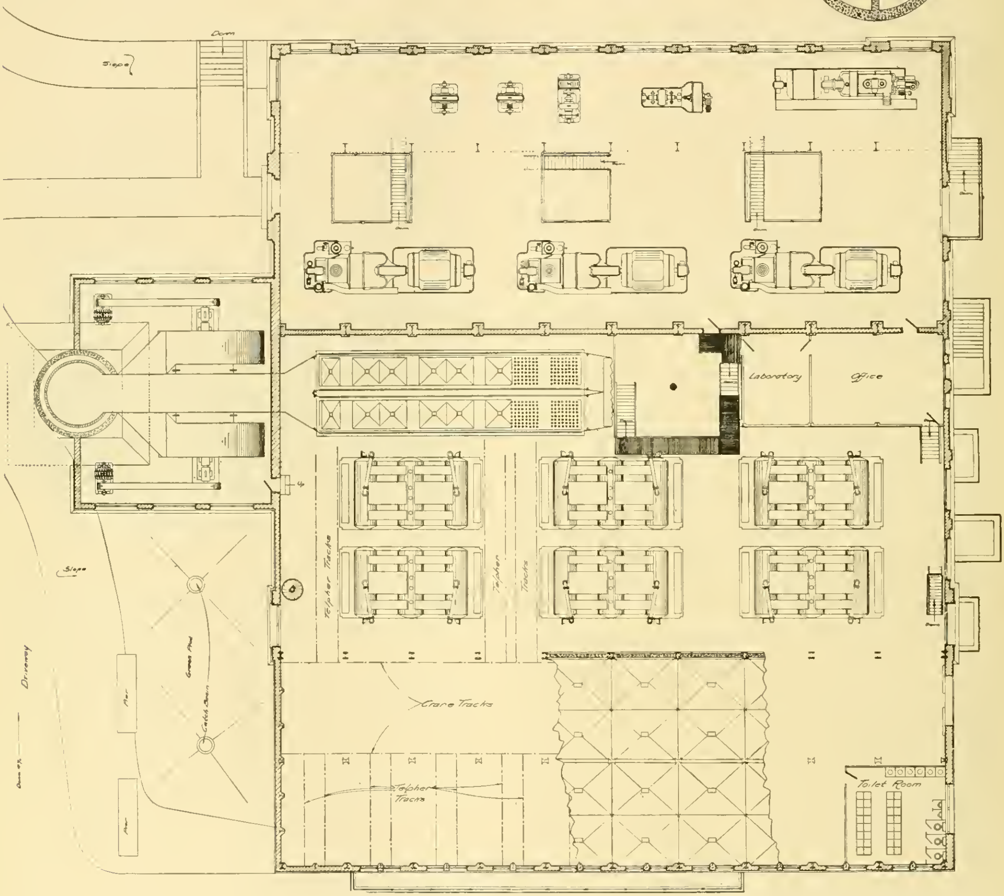



FIG. 2 FLOOR PLAN OF THE CLEVELAND MUNICIPAL LIGHTING PLANT

TABLE 5 EAST 53RD STREET POWER STATION REPORT, AUGUST AND SEPTEMBER, 1914

| OPERATION | August | Unit Cost | September | Unit Cost |
|---|---|---|---|---|
| Labor.......................... | $1,498.48 | $0.0018 | $1,573.00 | $0.0017 |
| Switchboard attendance.......... | 352.80 | 0.0004 | 380.00 | 0.00042 |
| Oil, packing and waste........... | ... | ... | 66.89 | 0.00008 |
| Sundry expense.................. | ... | ... | 10.46 | |
| Coal............................ | 2,686.50 | 0.0033 | 2,415.69 | 0.0026 |
| MAINTENANCE | | | | |
| Condensers, piping, etc........... | 5.48 | ... | ... | ... |
| Total operation and maintenance | $4,543.26 | $0.0056 | $4,446.04 | $0.0048 |
| Total kw-hr. generated........ | 809,120 | ... | 914,850 | ... |

The East 53rd Street station during these two months has been operating at less than one-fifth of its total capacity. The figures representing unit costs for the various items of labor, maintenance, fuel, etc., are, of course, considerably higher than can be obtained when the station is running up to its capacity, when it will be operating at a much higher efficiency in regard to coal consumption per kw-hr., and also the labor and other charges will be less per unit cost by reason of the larger output. During the month of August, the output of the Brooklyn and East 53rd Street stations amounted to 1,117,920 kw-hr., of which 936,467 kw-hr. were actually sold to customers, giving a loss in transmission of only 16¼ per cent, the average sale price for the kw-hr., generated being $0.0174 while the average sale price of what was actually sold was $0.0207; the revenue for the month being $19,405.38. The author states that an average load factor of 40 per cent on this station when the load is built up to its ultimate capacity seems to be assured, and in fact that a better load factor than this will actually be obtained. Prices charged for current for power purposes ranging from $0.3 down to a minimum of $0.01 become particularly attractive to factories, who are able to supply those conditions necessary for a good load factor, as is attested by the load factor which has already been secured on this station. A typical load curve is shown in Fig. 4. In this curve the peak load is shown to be only 2700 kw., but with a load factor of 80 per cent based on the peak load, there is a total output on the generating station of 51,925 kw-hr. If these conditions can be maintained, or even approximated, when the load on the station has been built up to its ultimate capacity, the load factor will be considerably greater than 40 per cent.

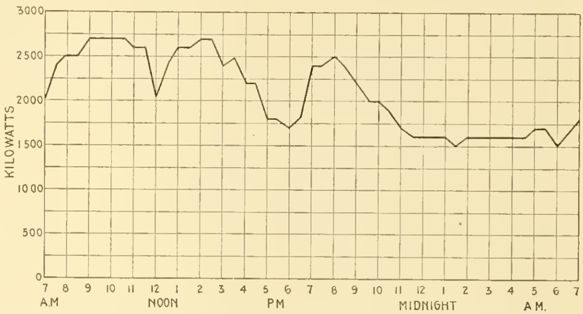



Fig. 4 Typical Load Curve, East 53rd Street Station

Fig. 3 Switchboard and 11,000-volt Compartment for Supplying Business District

EQUIPMENT OF STATION

The new plant has a maximum capacity of 25,000 kw. The special features in connection with the design of this station which are different from standard practice, are as follows: The use of motor-driven auxiliaries exclusively throughout the plant; the use of large boiler units with high steam pressure; the use of economizers of much greater capacity than ordinarily installed; a new arrangement of coal handling apparatus; the use of both forced and induced draft with practically atmospheric pressure in the combustion chamber; the automatic control of furnace conditions; the simplicity of the piping layout, due to motor-driven auxiliaries; and the use of an auxiliary steam turbine for driving the auxiliary motors. This turbine is supplied with a jet condenser, whose cooling water is the boiled feedwater before going to the economizers.

The large boiler units are quite similar to those in the Delray Station of the Detroit Edison Company, which have been described in great detail by D. S. Jacobus, in the Transactions of this Society.[1] The dimensions are identical with those of the Detroit boilers, except the length of the drums. These boilers are installed with 10,000 sq. ft. of heating surface each, and are designed to carry 275-lb. working pressure with a superheat ranging from 125 to 150 deg. fahr. They are equipped with Taylor underfed stokers, and are intended to be capable of operating up to 300 per cent of rating.

The operation of the boilers at a high percentage of rating means a higher temperature of flue gases. This, with the low temperature of feedwater, gives a temperature head between flue gases and feedwater which will be practically double that ordinarily obtained in economizer practice. This alone would be sufficient to warrant the installation of a larger amount of economizer heating surface. Another factor, however, is the low interest rate of 4½ per cent on the investment to be balanced against the saving produced in the economizers. These were installed by the Green

[1] Trans. A. S. M. E., vol. 33, p. 565.

Fuel Economizer Company and have a heating surface of 27,000 sq. ft.

The use of both forced and induced draught contributes greatly to the flexibility of the installation, and makes it possible to carry practically a balanced pressure in the combustion chamber, thus avoiding one of the greatest sources of loss in boiler practice, namely, the leakage of air through the boiler settings.

The turbine equipment consists of three units of Allis-Chambers-Parsons type, rated at 5000 kw. each, 1800 r.p.m., 11,000 volts, A.C., steam to be supplied at 225 lb. per sq. in. gage pressure, and 125 deg. fahr. superheat. The equipment of surface condensers was furnished by the C. H. Wheeler Company of Philadelphia. The power for the motor-driven auxiliaries is taken from a 1000 kw. turbine formerly in operation at the Brooklyn station, and will be operated in connection with a Le Blanc condenser, the cooling water for which will be drawn from a cistern used for the storage of the boiler feed water and which takes also the condensate from the three main turbines. The water in the cistern passes through the jet condenser several times before it goes as feedwater to the boilers and the connections are so arranged that the coldest water is supplied to the condenser and the hottest to the boiler feed system. The auxiliary motors in the station are connected through a double bus system so that each can be operated by current either from the auxiliary turbine or the main turbine. In this way the load on the auxiliary turbine can be adjusted so that the temperature of the feed water will be that best suited for delivery to the economizers.

Perhaps the most important innovation in connection with the operation of this station is not in the station itself. In central station practice in large cities it seems to have become a fixed rule to supply the congested districts with direct current through 220-volt 3-wire Edison systems, resulting in an enormous investment in copper, a much greater loss in transmission at the low voltages and also the loss of from 15 per cent to 20 per cent in transformation from alternating to direct current in the substations; and with the additional necessity of a greater number of substations than would be required for alternating current distribution.

It is a fact that nearly all lighting and power requirements can be met in the congested districts with alternating current as well as with direct current. There are, however, a few cases where the requirements can be met better with direct current but these constitute a very small percentage of the total. In power work there are places where finer gradations of speed control than can be secured with alternating current are desirable, and in lighting work there are places where storage batteries are necessary to provide an absolute security against interruption of service. But in such cases it would be much more economical to take care of the requirements on the premises of the customer and install there the necessary converters, accumulators, etc. The cost of this would be represented by thousands, whereas the investment necessary for the transmission of low voltage direct current from substations runs into millions of dollars.

In Fig. 3 is shown the arrangement of the 11,000-volt compartments and switchboard of the East 11th Street Station, which supplies the "down town," or the business district of Cleveland. The simplicity of the station and the absence of rotary converters is particularly notable when compared with the prevailing practice of supplying the congested districts of large cities from numerous substations in which are installed large numbers of rotary converters for changing alternating into direct current.

## DISCUSSION

Robert L. Brunet, in a contributed discussion, expressed approval of the method of operating the auxiliaries in the Cleveland plant. The objection to motor-driven units has been uncertainty of operation, which is removed by the single steam-driven unit which in this plant supplies power to the auxiliaries. He approved, also, of the use of both forced and induced draught in order to maintain a balanced pressure in the furnace.

As the author stated, the most important change in connection with the operation of the station is the use of alternating current for the congested business districts, instead of the Edison three-wire system. He knew personally of engineers of large central stations who find that there are practically no customers who cannot be properly and adequately served with A.C. as well as with D.C. current; and where the latter is absolutely essential, the transformation from A.C. to D.C. can be made on the customer's premises more economically than otherwise. There are important arguments against the use of D.C. current if high-voltage A.C. current can be supplied instead.

With low rates for current, both for lighting and power, it seems only fair to state that the load factor of 40 per cent will possibly be realized, based on a peak of 18,000 kw.; but when the peak is reached, the generating equipment will undoubtedly have to be increased in order to insure reliability and continuity of service. The load factor itself is dependent upon the diversity factor, i.e. the ratio of the sum of the separate maxima to the total co-incident maxima. In some stations where the load factor is in the neighborhood of from thirty to forty per cent, the diversity factor will be from 2 to 3 per cent—dependent primarily upon the means employed by the central station to obtain additional load.

The ratio of current sold for power to total power generated in modern stations varies from 50 per cent to seventy-five per cent and without this power business the rates for lighting would be decidedly increased to the small consumer. Engineers should not forget that a diversity factor in a station is the basis of profit and should receive the utmost consideration.

In making a study of the income of various central stations the writer has found that the income per dollar of investment varies in most private plants from 20 to 25 per

cent. Mr. Ballard has estimated an income of 33 per cent per dollar of investment. This seemed high to the writer, who thought it would be somewhat reduced by the fact that when the maximum of 18,000 kw. was reached the distribution system would be so extended that the actual investment would be greater than the figure used at this time.

The writer had prepared charts (not given herewith) showing the disposition of each dollar of income for a large private station and the estimated disposition of each dollar of income for the Cleveland municipal station. The private station has a capacity of approximately 350,000 h.p., with a total output of 840,000,000 kw-hr. per annum. The Cleveland plant has an estimated output of 60,000,000 kw-hr. per annum. In order to afford a close comparison the figures are tabulated below:

| | Private Central Station, per cent. | Cleveland Municipal Station, per cent. |
|---|---|---|
| Labor | 17 | |
| Materials, etc. | 23 | |
| Surplus | 7 | |
| | 47 | 36.40 |
| Dividends | 15 | 24.20 |
| Interest | 9 | 13.63 |
| Depreciation | 11 | 9.10 |
| Taxes and Municipal Compensation | 7 | 4.55 |
| Fuel | 11 | 12.12 |
| | 100 | 100.00 |

J. R. Cravath, in a written discussion, called attention to one of the features brought out by this paper regarding the low cost of modern steam turbine plants as compared with turbine or engine plants of like capacity a few years ago. A cost of $100 to $150 per kilowatt of maximum capacity was common in large city stations until very recently. The decreasing cost of steam turbine units per kilowatt and the increasing steam output to which boilers of a given capacity are being forced in common practice, together with the small ground space taken up by large turbine units per kilowatt, have combined to lower power station costs. A short time ago costs of $70 per kw. of station capacity were common for large steam turbine stations. In the present station, according to Mr. Ballard's figures, the cost of the station is about $1,000,000, which for a maximum capacity of 25,000 kw. corresponds to $40 per kw. On the basis of an 18,000 kw. peak load the cost is $56 per kw.

Figures given as to investment and operating costs correspond with estimates made by the writer on a station of similar capacity intended to operate under conditions of rather high load factor. The thermal efficiency which is assumed by Mr. Ballard is about 11 per cent. This corresponds to modern good practice in actual working conditions with the station fairly loaded. This efficiency in the best and largest modern turbine stations ranges from 10 to 13 per cent. The unusual method used in the supplying of good condensing water is in part responsible for the low cost of the plant per kilowatt.

Whether the estimated maximum load of 18,000 kw. can be brought to the station under conditions existing in Cleveland with a distribution system cost sufficiently low to bring the total investment to only $3,000,000 remains to be demonstrated. The cost of a central distribution system depends upon the character and distribution of the load. If the station can be fully loaded with a distribution system covering a small area and serving mainly large power consumers, the cost may be under that given. If the distribution system is to cover a large city where the load density is necessarily low because of dividing the business with a competing central station, existing experience indicates that it is very doubtful whether the station can be loaded to 18,000 kw. with a total investment of $3,000,000. The value of the power station being $1,000,000 leaves $2,000,000 for distribution system. With 18,000 kw. maximum load this corresponds to a cost of $111 per kw. for distribution system. On a similar basis the cost of the entire plant would be $167 per kw. of maximum load. It is probably not correct to take the cost of the Brooklyn system as a criterion of the cost of the 53rd Street plant with the distribution system when completed, but it is interesting to note that the Brooklyn system complete on a 1500 kw. capacity costs $365 per kw. of station capacity. If the station is not fully loaded the cost per kw. of maximum load would be higher than this. If we assume that the Brooklyn station alone cost $100 per kw. we would have $265 per kw. maximum load for distribution system investment. Distribution costs, in general, run from $100 to $300 per kw. As before explained, their costs will depend very much on the load and the size of the consumers. A large number of small consumers greatly increases the investment per kilowatt in distribution systems.

As Mr. Ballard points out, the economy of production is much dependent upon the attainment of a high load factor. A number of years ago, load factors of 20 to 25 per cent (annual) were common. This has gradually been brought up by the acquisition of additional power loads and in some cases by taking on street railway loads. A load factor of 35 per cent (annual) is high for a station supplying electric light and power alone and stations obtaining 40 per cent have done so usually at the expense of many years of strenuous work. It is possible that by cultivating the large power business and ignoring the low load factor lighting business a 40 per cent load factor might be maintained from the start in an enterprise like that at Cleveland. It must not be thought, however, that such a load factor represents an easy attainment. The natural tendency of such a rate would be to load up the plant with low load factor business unless great care were exercised to prevent it. We thus see the importance of the fundamental principle that the rates charged must bear some proportion to the actual cost of serving these classes of consumers.

In order to put this undertaking on a fair basis for comparison with a private corporation, 8 per cent is added for profit. In allowing 8 per cent profit in addition to 4.5 per cent interest, Mr. Ballard has apparently inadvertantly allowed considerable more annual return on the investment than would be necessary to clear him of a possible charge of unfairness to private corporations. Where commissions have passed on the question of reasonable return upon the investment in a plant of this character, the total annual returns, including both interest and profit, have been in the neighborhood of 8 per cent rather than 8 per cent in addition to interest. Mr. Ballard's fixed charges therefore should be reduced 4.5 per cent.

Fixed charges, depreciation and interest on the Brooklyn

plant with an investment of $548,182 is given as $19,079. This is only 3.6 per cent on the investment and appears to be an error. From the information given in the discussion, the depreciation on the Brooklyn plant would be considerably higher than for the 53rd Street plant inasmuch as a part of the Brooklyn plant investment would be written off as it is replaced by the 53rd Street station.

Depreciation on the complete plant is assumed at 3 per cent, calling for an average life of plant of 22 years. It is doubtful whether this is a sufficient allowance for depreciation even though it may be in accord with the customs of some private corporations. In the Madison Gas and Electric Co. case before the Wisconsin Railroad & Public Service Commission in 1910, the commission decided that the average life of the electric plant was about 17 years.

One element of first cost which can only be determined after the undertaking has reached the state of development anticipated in the preliminary estimates is that classified by the Wisconsin Commission as going value. Under this head is included whatever loss in operation is incurred in the early years of operation before the load has been built up to a point to yield a proper interest and profit on the investment. This amount must needs be added to the tangible physical investment to determine the total money put into the property.

Walter C. Allen wrote that the paper omits a description of one of the features most interesting to electrical men, viz.: the distribution system. Apparently the new 53rd Street station is delivering its energy to the existing distribution system through the East 11th Street sub-station, without the use of rotary converters.

The loss in distribution from the Brooklyn station for the year 1913 as given is 27.4 per cent, while the loss for the first eight months of the present year, with the 53rd Street station operating with it during the last six weeks of that period, is 20.2 per cent. The loss during the month of August with both stations operating, is given as 16.25 per cent. In the absence of any further information regarding improvements in the distribution system, the reader must assume that this increased efficiency is brought about by the use of alternating current in the low tension system, instead of direct current through rotary converters.

It will be interesting to see what further efficiencies are obtained from the new distribution system, for which it appears $1,500,000 is available.

Alex. Dow said that he had followed the construction of the Cleveland plant with a great deal of interest. It is in a neighboring town, the consulting engineer is an old friend, the plant is a good one and a credit to the author. There is, however, much in the paper that is speculative. He hoped that at a later time when the proof of the performance of the plant was completed, the results, whatever they might be, would again be placed before the Society. At present, there is lacking a distributing system for the plant, there is lacking a load, and accounts kept in a manner which would be acceptable to a Public Service Commission. When these are realized we shall know the answer to the question of what the plant is accomplishing.

He further called attention to the author's statement of engineering matters, with no implication of lack of truth, but because of slackness of expression which could not be overlooked when made by an engineer before an audience of engineers. An examination of the figures given shows the continuous duty of the station to be 18,000 kw. with good luck. He questioned the claims made for new and radical features. The record plant with which every engineer is familiar is at Dunstans, with the auxiliaries motor-driven throughout. The boilers of the Cleveland plant are rather less than half the size of those of the same type at Delray which have been in service five years and there is nothing radical in the increase of steam pressure from 225 to 275 lb. The balanced draft he remembered to have seen in use in torpedo boat practice when he was a "cub" on the Clyde.

Another inaccuracy is in reference to the figures upon the kilowatt hours generated. A note should be inserted that something like 10 to 15 per cent of this power is used in the station itself.

Edward W. Bemis[1] in a written communication stated that he believed no candid student of the subject could doubt that Cleveland by its municipal control in various matters is securing better results than state regulation would secure. In the case of the Cleveland street railways certainly and until now, at least, in the case of the private electric light plant there, it has not deprived the private company of a fair return on its actual investment in the property, using investment to cover moneys furnished by the stock and bond holders in addition to good dividends from the start.

At the November Conference of Mayors in Philadelphia, Mayor Hocken of Toronto declared similar results were being secured by similar methods there. If these experiments continue to succeed, it is evident that state regulation will have to cease allowing companies returns on unearned increments, donation and surplus earnings invested in their properties, or existing laws in the various states will be changed where necessary to permit direct municipal competition under proper safeguards of publicity and uniform accounting, referendum on bond issues, etc.

It will be recalled that this method of potential municipal competition was endorsed by the National Civic Federation Commission on municipal versus private management, in 1907, as the most effective method of control.

When the efficiency of public operation approaches that of private operation, the handicaps upon the latter, through its demand for returns which public operation never makes, such as going value, and the increased cost of replacement as compared with actual cost, etc., to say nothing of differences in the demanded rate of return, will prove serious. Whether that time has yet arrived, and how far private companies will awake to the situation, as they have been doing in England, will vary with every community and with changing conditions.

R. P. Bolton, in a written discussion, said the first thing to be considered is the foundation upon which the economic features of the plant are based. He called attention to the author's statement that the South Brooklyn Station had "made the remarkable record of having acquired more than one-half of its total value in eight years from the earnings of the plant itself" and said that so far as the details

[1] 4500 Beacon St., Chicago, Ill

of these earnings are made available in the paper itself he felt that the diversion of such earnings was not warranted.

According to the figures of the author, the capital investment to the end of 1913 was $320,796 and the amount added from the earnings prior to providing for necessary fixed charges was $306,533, or a total of $627,329.

This account is credited with $109,147, which could or would have been paid to a local company for street lighting. This amount, however, almost exactly offsets a book charge for depreciation of $113,244 so that any money for the latter necessary purpose has been burnt up and the value exists only as a book debit. The character of part of the earnings may be seen by comparing the figures of operating income in Table 3 with the item for 1913 in Table 2. The net earnings for 1913 were $68,979; earnings put back in the plant, $66,622; which leaves only $2,357 to pay fixed charges of $19,079.

The income of the South Brooklyn plant had been secured in 1913 by an average sale price of 3.28 cents per kw-hr., while for the first eight months' operations of the old and new stations the rate had decreased to 2.44 cents per kw-hr.

| | |
|---|---|
| The direct loss on the South Brooklyn system is therefore 84/100 of a cent, and allowing for the economy in production cost due to the new plant's operation, the net loss is............ | $31,100 |

Turning to the figures of operation of the new plant, we find:

| | |
|---|---|
| The earnings for August were, at the average rate of 2.07.................................. | $19,405 |
| Average of 8 months monthly operating cost..... | 12,130 |
| Leaving for administration and fixed charges.... | 7,275 |
| The fixed charges are stated to be per month..... | 22,500 |
| Resulting in a deficiency, for the month, of...... | 15,225 |

It is upon this somewhat ricketty foundation that the basis for estimating results in the 53rd Street Station has been predicted.

The writer contends further that the successful financial operation of the plant is dubious, not only by reference to the data upon the operation of the Brooklyn station, but also in consideration of the character of the service to be rendered and the rates to be charged.

The service is to be for alternating current only, which for much of the business of Cleveland will be unattractive and much direct-current machinery will have to be altered or discarded for its adoption.

Details of the rates are not given in the paper, but from those which he has found in the records of the municipal council he believes they are such as to offer but little inducement to those customers whose usage is the most desirable in producing a high load factor. A diagram plotted by the writer indicates that the inducements of the rates are toward high connected capacity which is a source of production of high peak and low load factor.

He asked: Are there any data in the paper which justify the expectation that the small consumer can be served at the rate of 3 cents without loss, which must be borne by other consumers or by a deficit in operation? The total costs of the 936,000 kw-hr. sold in August were, without administration, $34,630, or, per kw-hr. 3 7/10 cents. The figures made public by the Detroit Edison Co. show their cost of service connection, upkeep, meter installation, lamps, accounting and bill to be per customer $8.41 per annum. This is over and above the cost of producing and delivering the energy used.

The Author said that he had been told so often that they were radicals up at Cleveland that he was glad to learn that Mr. Dow did not consider anything in this station to be at all radical and that they had built a plant so nearly like the Delray station. There was no reason why the latter should not sell their current at the same price as the Cleveland station and he hoped to see them do it.

With regard to the capacity of the station, there is some degree of uncertainty in the method of rating power station machinery and power stations. He understood that stations at the present time are generally rated upon their maximum continuous capacity. Tests showed that these turbines are capable of 7500 kw. continuous capacity; three of them would give 22,500 kw. and the auxiliary machine would add 1500, making 24,000 kw. maximum continuous capacity. That was the basis on which he had made all his statements in regard to capacity.

In Mr. Cravath's discussion, the figure of $365 is the cost per kw. of the entire Brooklyn plant, including the distributing system. As shown by the appraisal, he thought the value of the distribution system was about $200 per kw. and of the station itself from $160 to $175.

As to whether it will be possible to get a 40 per cent load factor, the system is now running with between 60 per cent and 80 per cent load factor and while he realized that as the load was built up they would secure a much poorer load factor, he believed it would not go below 40.

The question has been raised in regard to cost per kilowatt-hour. It is true that this differs greatly for different classes of customers and the Cleveland plant is radical in that respect in that it is selling current to some customers at a loss.

The waterworks department at Cleveland is selling water at a uniform rate to everybody, the smallest household user as well as the factory. That is probably going to the other extreme, but they are subject to no competition. Of course, this cannot be done with electric current. Outside of the question of competition, if there were only one station and every customer had to take that current or none at all a single rate could not be maintained. Current could not be sold to the small residence customers at as low a rate as it would be necessary to sell to power customers and the business could not be obtained, on the other hand, if power customers were charged at a higher rate than residence customers.

Mr. Bolton raised a question as to the $66,000 reported turned back into the plant from earnings, whereas $49,000 is shown in the report as profit. This, however, is correct although it appears on the books in the way of depreciation. Many companies are mistaken at the present time in setting up 10 or 15 per cent for depreciation year after year. The point will soon be reached where the book value of the plant is very much less than the actual value. He instanced the case of a large company, the plants of which he had appraised, and found the value to be thousands of dollars more than their books showed, simply because they had been writing off too much depreciation. This method of setting up depreciation was followed with the Brooklyn plant and is where the difference comes in between the $49,000 and the $66,000.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

The war in Europe has materially affected the files of foreign periodicals. While most of the papers come in with fair regularity, both their size and intrinsic value of contents have suffered to a noticeable degree. The Belgian papers have been discontinued entirely, the French appear in a reduced size, while most of the German papers have adopted the system of publishing double numbers, sometimes with less reading matter than the former single number. When, however, one sees the long lists of the members of various engineering societies fallen on the fields of battle, one has no difficulty in understanding the decrease in the output of papers.

### THIS MONTH'S ARTICLES

The investigation of a gas-driven compressor air plant at the Mine Consolidation is of interest because it is the first large air compressor plant so driven in Germany, and while there is nothing startling in the results obtained, the overall efficiency of the installation is fairly high.

Attention is called to the article on Pelton turbines, especially because it is believed to be the first authentic information on the Fully plant, using the highest head of water, in a single jet, in the world. In the same abstract, data are given on the Dufour water wheel governor.

In connection with an article on a 1000 h.p. Diesel engine is reported a method of governing the pressure of the fuel injection air, which will facilitate the use of Diesel engines on constantly varying loads, such as are met with in central stations supplying energy to tramway systems.

The article on elastic hysteresis does not present anything essentially new, but it is reported here because it refers to a matter to which hardly enough attention has been given in American engineering papers.

The section on steam engineering contains several interesting articles. Tests are reported on the use of eddy rings, a device somewhat similar in shape, though different in action from what is known in this country as retarders; data on accident in gas fired boilers are reported, and a new type of traveling grate is illustrated and described. Further, a new type of liquid fuel burner, of the adjustable kind, is described, it is also stated that this type of burner has been a success in the Austrian navy.

In the last section the Plumboxan process of producing oxygen and nitrogen is described.

In the section Engineering Societies, the following papers are reported or abstracted:

E. S. Christian, in a paper before the American Wood Preservers' Association, gives data on the preservation of a pier at Newport News, Va., against the action of marine borers by means of dead oil, the pier having withstood the attacks of the borers now for 32 years.

J. H. Waterman presents data on ties treated by various processes such as the Full Cell creosote, zinc chloride, Wellhouse and Card processes. Also a specification for a coal tar creosote solution is reported.

Milton L. Sims, in a paper before the Central Railway Club discusses the matter of painting of steel cars and locomotive equipment and many other things, giving schedules of time for various painting jobs.

In a paper before the Corps of Engineers of the United States Navy, Captain W. A. Mitchell presents important experimental data on the percolation and upward pressure of water necessary in order to design dams properly.

Tests on various reinforced concrete structures in England are reported in a paper by J. B. Hall before the Institution of Civil Engineers. Before the same body, S. H. Ellis presented a paper on the corrosion of steel wharfs at Hongkong, China, containing data which may be of interest to any engineer working in the tropics.

Particular attention is called to the paper by Thomas Bryson before the Institution of Mining Engineers, on the testing of fans with special reference to the measurement of pressure, and containing other things and valuable data on the efficiency of various forms of water gages.

Genjiro Hamabe, of the College of Engineering of the Kyoto Imperial University, discusses the disturbing actions of a shaft governor. While the paper is too mathematical to be fully abstracted in some of its parts, an attempt has been made to present the main line of reasoning of the author in a moderately readable form.

The two papers by Professor B. Hopkinson, on the charging of 2-cycle internal combustion engines and H. F. Fullagar on a new type of internal combustion engine before the Northeast Coast Institution of Engineers and Shipbuilders refer to tests on the same engine, but Professor Hopkinson's paper takes up the entire subject of charging, which he discusses in a novel and highly interesting manner.

The analysis of coal with phenol as a solvent by S. W. Parr and H. F. Hadley gives not only a method of coal analysis but presents data of material interest to all those who have to do with the utilization of coal in a boiler, furnace, coke oven or gas producing plant.

## FOREIGN REVIEW

**Air Machinery**

Investigation of a Gas Driven Air Compressor Plant at the Mine Consolidation.

The article describes a gas engine driven air compressor installation at the Consolidation mine in Germany and gives data of tests of this installation.

While gas engines have been used widely to drive electric generators, their use for air compressor operation in Germany appears to have been very small and only in installations of an experimental nature. The present installation, therefore, represents a very bold advance involving a compressor handling per hour 15,000 cbm. (say 530,000 cu. ft.) from atmospheric pressure to a pressure of 6 atmospheres gage. The gas engine is a four stroke cycle twin tandem engine working on coke-oven gas with a heating value of from 4,000 to 4,500 WE, (448 to 504 B.t.u. per cu. ft.). The high pressure and low pressure cylinders of the air compressor are directly connected to each of the sides of the gas engine, each side of the engine being so designed that it can compress as a single stage compressor from 4800 to

7000 cbm. (169,500 to 247,200 cu. ft.) per hour to a pressure of 5 atmospheres, according to whether the high or low pressure cylinders are operated. The arrangement is such that even when the engine is being cleaned, or undergoing repairs, the compressor is still partly running.

When the engine is operated at its full capacity of 15,000 cbm. per hour it has a speed of 90 r.p.m. The compressor has Horbiger-Rögler plate valves conveniently located in a valve chamber in such a way that they can be easily exchanged. In order to attain as low an air temperature as possible and, further, in order to comply with the police requirement that the temperature in a single stage compressor should not exceed 140 deg. cent. (284 deg. fahr.), the walls of the compressor as well as the compressor piston are water-cooled. The intermediate cooler which permits the cooling down of the partly compressed air to the temperature of suction is placed in the floor in an accessible position. A tube filter of the Blass type is used for cleaning the air in suction.

TABLE 1 TESTS OF A GAS ENGINE DRIVEN AIR COMPRESSOR EQUIPMENT

| | |
|---|---|
| Duration of test, hr. | 6 |
| Barometer pressure, mm. water | 753.75 |
| Temperature of air sucked in, deg. cent./fahr | 13 25/55.9 |
| Temperature behind the low pressure cylinder, deg. cent./fahr. | 102.8/217.1 |
| Temperature behind intermediate cooler, deg. cent./fahr | 31.4/88.6 |
| Temperature behind high pressure cylinder, deg. cent./fahr | 112.8/235.1 |
| Compressed air pressure, atmospheres gage | 6 6 |
| Volumetric efficiency of compressor, per cent | 87 7 |
| R.p.m. | 90 6 |
| Air output of compressor, cbm/cu.ft | 15,277/539,493 |
| Power consumption of compressor, i.h.p. | 1479 |
| Indicated output of gas engine | 1774 |
| Mechanical efficiency of the plant, per cent | 83 4 |
| *Low pressure side:* | |
| R.p.m | 73 5 |
| Volumetric efficiency, per cent | 49.9 |
| Air output per hour, cbm/cu. ft. | 7051 6/249,004 |
| Compressed air pressure, atmospheres gage | 5 1 |
| Average temperature of compressed air, deg. cent./fahr | 138/280 |
| *High pressure side:* | |
| R.p.m | 87 3 |
| Volumetric efficiency, per cent. | 72 9 |
| Air output per hour, cbm/cu.ft. | 4767 2/168,345 |
| Compressed air pressure, atmospheres gage | 4.9 |
| Average temperature of compressed air, deg. cent. fahr | 138 280 |

The engine was subjected to an acceptance test in the period from September 29th to October 4th, 1914, and a further control test on October 13th. The work of the cylinders of the gas engine and compressor were determined by indicating the air pressure and temperature by properly calibrated manometers and thermometers, while the heat content of the gas was determined by analysis and by means of a Junker calorimeter.

In order to eliminate the influence of outside temperature and the action of sun rays on the gasometer, all the tests were carried out after the sun went down. Nevertheless it has been found in testing the air tightness of the gasometer that the pressure lever continued to sink after sundown and this led to the control test on October 13th. The data of the test are shown in Table 1. This test has shown that the plant as it stands did not satisfy entirely the very exacting requirements of the contract but that it was fairly efficient. During the entire test, the engine ran quietly without causing any trouble, and no disturbances of any kind in the operation of the plant were observed. (*Untersuchungen des Gas-Luftkompressors auf der Zeche Consolidation*, report of the Boiler Inspection Society of the Mining District of Dortmund at Essen, *Glückauf*, vol. 50, no. 51, p. 1717, December 19, 1914, 4 pp., 5 figs., *de*).

### Hydraulics

#### Pelton Turbines and Their Governors.

The article (continuation of the one abstracted in *The Journal*, January 1915, p. 44) describes Pelton turbine installations in Saaheim, Norway and Fully, Switzerland.

The installation in Norway was built for a fall of 253 m. (830 ft.) and an output of 16,400 h.p. at 250 r.p.m. It is a turbine with two wheels and two needle nozzles per wheel. The average diameter of the wheels is 2.4 m. (94.4 in.), the number of blades, 26, and the maximum diameter of the jet, 0.164 m. (6.4 in.). A figure shows the disposition of the nozzles, water admission to them and regulation and distribution of the blades in the wheel, the casings with the foundation frame and the arrangements for letting off water into the shaft. Fig. 1 A indicates the method of holding the blades.

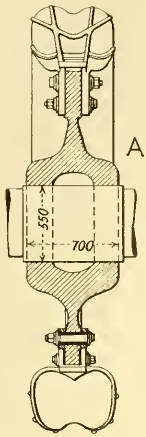
The turbine is equipped with a combined needle displacement and jet deflection in accordance with the Leon Dufour patents. Fig. B, p. 45 indicates the method of operation of this system of control in a manner which permits its comparison with the method of control indicated in Fig. C, p. 45. *The Journal*, January 1915. The rocker *abc*, with the rigidly located center of rotation at *b*, is, at *a*, connected with the pistons of the servomotors. At *c* is suspended the first main element of mechanism, viz. a bar *cd*, bent in accordance with the predetermined curve, this bar being connected with the needle rod by means of the deflector *de*. The bar is further connected with the jet deflector by means of a rod *ik*. The servomotor consists of two parts, viz. of the main servomotor, equipped with a differential piston and a displaceable pressure servomotor located coaxially with the main. The casing of the latter is inserted into the smaller working space of the main servomotor so that an axial displacement of this casing is possible. The piston of the pressure servomotor is connected rigidly and invariably with the piston of the main servomotor, while this casing is connected by means of the guide *fg* with the jet deflector. With the rigid bearing of the rocker *abc* is connected a roller which limits the deflection of the bar to the right.

From the above description and Fig. B (which, however, represents the construction only diagrammatically), it is clear that as long as the permanent contact is maintained between the bar and the roller, each position of the piston, 0, 1, 2, 3, 4, of the main servomotor corresponds to a definite position indicated by similar numerals of the deflector edge $\sigma$.

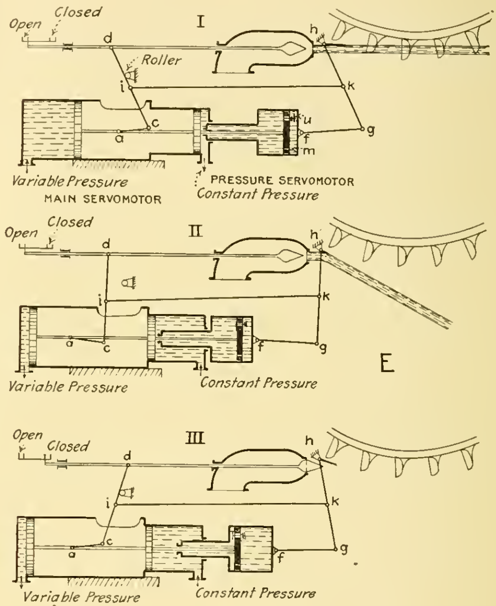
The Pelton turbine of the Fully plant is of the greatest interest because in the plant, a total flow of 1650 m. (5412 ft.) between the Lake Fully and the valley of the Rhone is utilized in one stage, which naturally leads to the necessity of solving some quite interesting problems in the selection of materials and design of piping for stresses produced by such a head. No complete data have been published as to the method of conveying the water and of the piping. The author is only enabled to state that the total piping is 4625 m. (15,172 ft.) long; that its upper part, 2300 m. (7545 ft.) long uses a diameter of 0.6 m. (23.6 in) while in the remaining lower part, the diameter is 1.5 m. (19.6 in.);

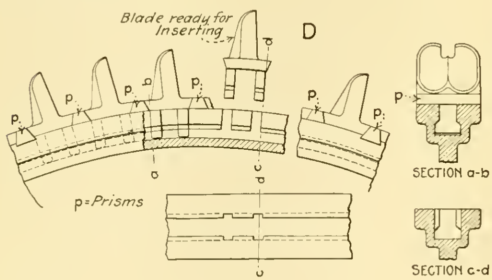
that the thickness of the walls of the pipe varies from 6 mm. (0.23 in.) to 43 mm. (1.69 in.). Up to a thickness of 34 mm. (1.33 in.), the steel piping has been produced with longitudinal and cross seams welded by a special process. The piping of a thickness of 34 to 43 mm. consists of pieces drawn from single block without longitudinal seams and combined into pipe sections by autogenous welding, the connection between such sections being made by welding on connections with loose flanges and rubber ring packing. The entire main piping is located underground and is covered with earth at least 1 m. deep.

The prime movers consist of five units of 3000 h.p., each driving polyphase generators operating at 10,000 volts and 50 cycles. The turbine installation as shown in the original article has a runner of 3.55 m. (11.65 ft.) theoretical diameter with 54 pressed steel blades. The method of fixing and holding the blades is shown in the lower left hand section of Fig. D. The 54 blades are distributed into nine groups of six blades each, such groups being separated by trapezoidal prisms.




indicated by similar letters. Fig. E shows also the fundamental geometric conception of the device characterized by the parallelogram consisting on one hand of the rocker *dc*, between the servomotor and needle rod, and the rocker *hg*, parallel to *dc* when the nozzle is fully open and connecting the pressure servomotor and jet deflector; and on the other hand, first, by the parallel axes of the servomotor and, second, the needle. In other positions of the needle and deflector, the parallelogram becomes an irregular quadrangle in which the two sides formed by the axes of the servomotor and the needle remain parallel but are of different lengths, while the axes of the rocker depart from their parallel positions.



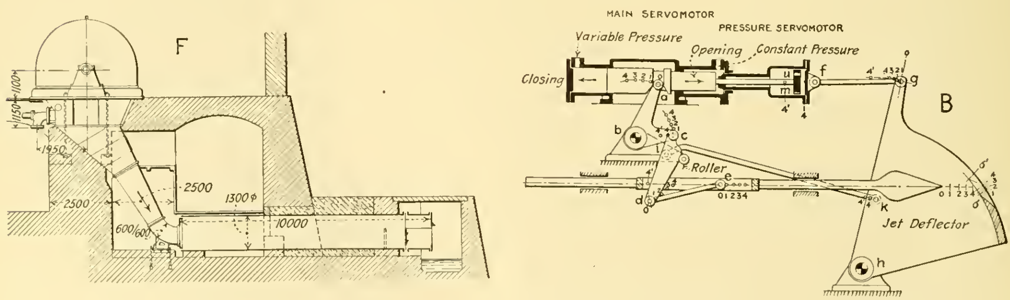




Fig. 1 Pelton Turbines, their Blades and Governors

This turbine is equipped with a combined Leon Dufour regulation similar to that described above but its actual construction, as indicated in Fig. E, is different from that used in the preceding case. In order to make the comparison between Fig. E and Fig. B easier, similar parts are

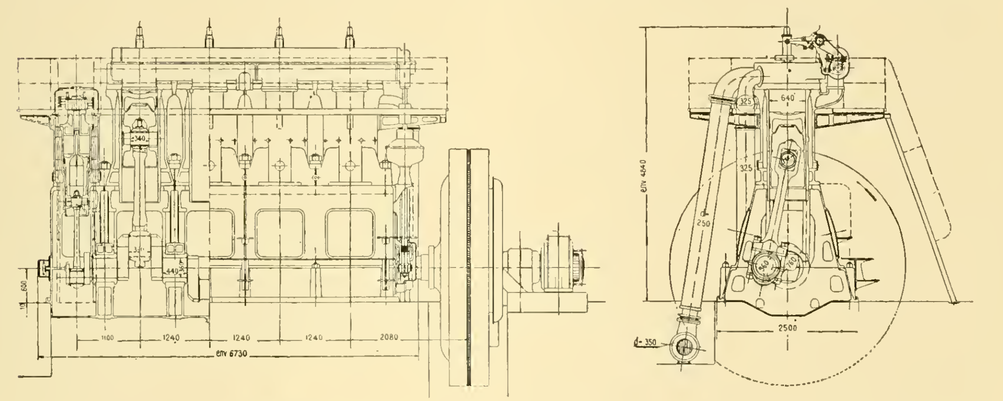
With the fall of 1650 m. available, the velocity with which the water leaves the nozzle is somewhere around 180 m. (590 ft.) per second and even after it leaves the wheel, it still has a velocity of from 35 to 40 m. (105 to 131 ft.) per second. It is of particular importance therefore that the

water should not strike the walls of the outflow shaft, and an arrangement resorted to is shown in Fig. F. It consists of a special cast iron shield on the upper end of the shaft and close to it, a sheet metal passage, located in an inclined position with a contraction toward the lower part, into which the various grids are built and which opens through a quarter bend into a horizontally located sheet metal cylinder 10 m. (32 ft.) long and 1.3 m. (51 in.) in diameter. (*Die Wasserturbinen und deren Regulatoren an der Schweiz. Landesausstellung Bern,* 1914, Professor Franz Prášil, *Schweizerische Bauzeitung,* vol. 64, no. 24, p. 257, December 12, 1914, serial article, not finished, *d*).

### Internal-Combustion Engines

#### 1000 H.P. Diesel Engine

The article describes in addition to heat and refrigeration engines at the National Swiss Exhibition of 1914 at Berne, a 1000 h.p. Diesel engine of a rather interesting type. (Fig. 2)



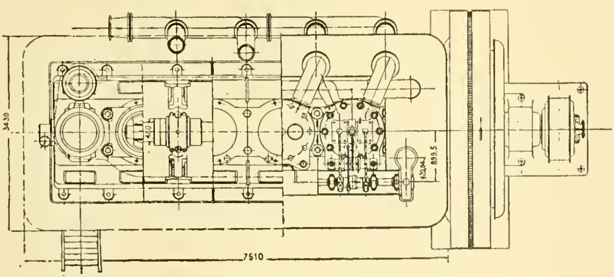


Fig. 2 A 1000 H.P. Diesel Engine

The engine is of the four-stroke cycle type with four fixed cylinders. In addition to a judicious disposition of the cylinders held by vertical steel tie-rods, the engine has also an automatic regulation of the pressure of the fuel injection air. To make the combustion more perfect, this pressure has to be regulated in accordance with the charge. In this case, the speed governor of the engine provides for this kind of regulation. To each load there corresponds a certain predetermined position of the governor sleeve and this, by means of a cylindrical valve, permits the throttling, more or less, of the admission of air into the first stage of the fuel injection compressor. The variable initial pressure causes a fluctuation of the final pressure which later attains a maximum for large charges and is reduced by about one-third for small charges. Further, by means of a servomotor and through a variable pressure at one of the stages of the compressor which delivers the air of injection, it is quite possible to regulate the motion and the time of opening of each fuel valve. As a result, the air of fuel injection can penetrate into the working cylinder only in quantities fully subject to regulation, so as not to be in the way of the propagation of the flame at the instant of the combustion of the injected fuel.

The air of injection should always have a pressure several atmospheres above that which exists in the cylinder at the end of compression. If this air has been sufficiently cooled after each compression, it will have essentially the temperature of the surrounding medium, and the latter will, to a sufficient extent, go down during the expansion, to cause a considerable cooling and to provoke not only a defective combustion, but if the air of injection enters in too large quantities, a failure of ignition, which in its turn can cause grave disturbances in the regulation and make working in parallel impossible. The Sulzer regulation entirely eliminates this cause of trouble and permits the building of motors for constantly varying loads, such, for example, as in central stations supplying energy to tramway systems, etc. *Les machines thermiques et frigorifiques à l'Exposition nationale suisse de 1914, à Berne,* Professor J. Cochand, *Bulletin technique de la Suisse Romande,* vol. 40, no. 23, p. 261, December 10, 1914, serial article, not finished, *d*).

### Mechanics

#### Recent Experiments on Elastic Hysteresis.

Discussion of phenomena of elastic hysteresis in solid bodies.

When a solid body is subjected to an elastic deformation within certain limits, the deformation is exactly proportional

to the force applied. This region of deformation is known by the name of Hooke's, and its limit is called the limit of elasticity. It has hitherto been accepted in the theory of strength of materials that an elastic deformation within the Hooke region is reversible, even though there are certain phenomena which contradict this view, such for example, as the fatigue of materials. Lately, however, by the application of especially delicate methods of observation, the processes occurring in elastic deformation within the limits of elasticity have been better investigated experimentally, and it has been found that the proportionality between deformation and force applied, as expressed by the Hooke law, does

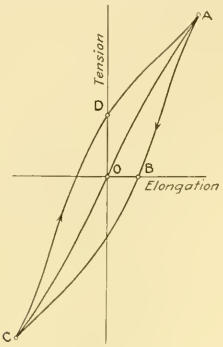



Fig. 3 Hysteresis Loop of Elastic Deformation

not hold good exactly, and one cannot strictly speak of the reversibility of this process. On account of the similarity of the processes (see the tension-elongation diagram in Fig. 3) with magnetic hysteresis, this phenomenon was called elastic hysteresis. It may be explained by the assumption that the deformation lags behind the force so that if the point of reversal be suitably selected, a closed curve process can be produced.

In the above diagram $OA$ is the virgin line of the material newly stressed in tension. $ABC$ shows its contraction down to the state $C$ and $CDA$ the more recent expansion into the state $A$. The curve becomes a closed one when $A$ and $C$ are symmetrically located with respect to the zero point and in further cycles of the process practically the same path is repeated over and over again in the direction of the arrow. Further, since the energy of a unit of volume of a body elastically deformed is given by the expression $\int \sigma d\varepsilon$ where $\sigma$ is the stress, and $\varepsilon$ the deformation, the area of the hysteresis loop in a circular process is numerically equal to the work lost per unit of volume, such work having been partly transformed into heat and partly used up on the displacement of the molecules, and has thus possibly led to the rise of fatigue in the material.

It may be added that this phenomenon occurs in as pure a manner as here indicated only when the stresses remain within the Hooke region and when so large a number of these cyclic processes have been gone through that the material has sufficiently adapted itself to the process. In addition to that, the hysteresis phenomena are always superimposed by the so-called elastic reaction which after each application of strain permits the molecules to assume their initial position of rest only after the lapse of hours and sometimes days.

The author proceeds to the presentation of data on elastic hysteresis obtained by Professors Hopkinson, Trevor-Williams and F. E. Rowett in their tests in the Engineering Laboratory in Cambridge which were published in the Proceedings of the Royal Society of London, Ser. A, vol. 87, p. 502, and vol. 89, p. 528. (*Neuere Versuche über elastische Hysterese,* Dr. R. Grammel. *Zeits. des Vereines deutscher Ingenieure,* vol. 58, no. 48, p. 1600, November 28, 1914. 3 pp., 3 figs. *te*).

**Steam Engineering**

Boiler Accident

The article describes an accident to a boiler fired with producer gas.

It is taken from a report of the Mountain Boiler Inspection Association of Barmen, Germany. The boiler was of the double flue type, fired with producer gas, with the steam collector in the upper flue. 100 sq. m. (1076 sq. ft.) of water heating surface and 6 atmospheres licensed pressure. Up to the time of the accident, the boiler had been in operation for nearly 7 years. The gas was developed in a coal gas producer located in the boiler house, while the combustion chamber was directly in front of the boiler. The first rings of both flues were covered with fire clay lining with an inner diameter of 580 m. (22.8 in.). According to the general regulations for licensing gas fired boilers, the ratio of grate area to water heating surface (such "water heated surface" being that which the heating gases play on, before they reach the heating surface in contact with the steam) was determined on the basis of an ideal grate area of 2.1 sq. m. and a ratio of grate area to heating surface as 1:47.5. The air was forced into the combustion chamber by a fan. When the plant was licensed in 1905, the minimum cross section of draft was used for the determination of the ideal grate area, as in the inspection regulations at that time, there was no precise indications as to the methods of calculating the grates.

In June 1913, the boiler was cleaned, but this cleaning had to be done with great speed as another boiler which was also fired by producer gas met with an accident in the meanwhile. After the boiler had been started again, it was fired at a high rate for 24 hours, but it was found impossible to obtain any noticeable pressure. At the same time, the evaporation appeared to have been quite strong as it was necessary to supply feed water all the time. When the fire was allowed to go out, it was found that the parts of the boiler shell and the steam collector shell in contact with steam must have been red hot. The shell girth seams had been drawn apart, so much that one could see through them into the inside of the boiler. The steam collector shell indicated strong outward bulging, while the front sheet of the collector was blown out into a hemisphere. The steam which was produced during the heating evidently escaped through the openings in the seams at a very low pressure into the upper flue and thence into the smoke stack.

Investigation has shown that the accident was due to the after-burning of gases in the upper flue which had not been burned entirely in the combustion chamber on account of lack of air. It is quite impossible that the temperature

of the hot gases, after complete combustion in the combustion chamber, should have been so great when coming in contact with the steam heating surface that it could have produced such effects as were found in the boiler. It is quite possible, however, that the after-burning was helped also by the air coming directly into the upper flue. This accident indicates that in boilers precautions should be taken to prevent the steam heating surfaces from being acted upon by the hot gases, as incomplete combustion of the gases in the combustion chamber is always possible. *Aus der Überwachungspraxis, Zeits. für Dampfkessel und Maschinenbetrieb, vol.* 37, no. 51, p. 544, December 18, 1914, 1 p., *dp*).

### Eddy Rings in Firetube Boilers.

The article reports tests with eddy rings, a special device for increasing the efficiency of boiler fire tubes.

The action of eddy rings provides for deflecting that part of the gas stream flowing through the fire tubes of a boiler which is nearest to the walls of the tube and therefore coldest and in this way mixing it with the hotter part of the gas stream, thus securing a fuller exchange of heat between water and gas. The construction of the eddy rings is shown in Fig. 4A. From it, it is seen that the action of the eddy rings

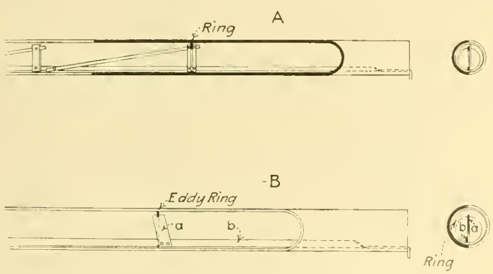



Fig. 4 Eddy Rings for Marine Boiler Tubes

is essentially different from that of retarders, in which the gas stream is divided into two parts and is given a helical forward motion, without, however, enabling the inner hot gases to reach the walls of the tube.

The first tests with eddy rings of the Pielock system were made in 1910 and on the whole, have been successful. It is now stated that 50 ships have been equipped with the Pielock rings. The article gives detailed data of tests made with and without Pielock rings on various steamers, mainly barges and tugs. It may be of interest to state here that the first Pielock rings were installed on the condition that the coal saving should be guaranteed at not less than 10 per cent; that a fine of $50 be paid by the company installing the rings for each 1 per cent of saving of coal less than 10 per cent and that should the saving in coal not reach 5 per cent, the company would take out the rings free of charge and defray the entire cost of the test. Under these rather severe conditions of contract, a saving of 15 per cent was effected.

As an example of the various tests reported in the article, we may select those made with three tug steamers, Moritz, Otto and Ernst (Table No. 2). The trips were all made against the tide, drawing one barge of approximately equal load in each case and using the same kind of coal in the boilers.

The author states that eddy rings can be used also in superheaters, a part of the tube cross-section being occupied by the superheater coils. It is necessary, however, in such a case that the free section of the tube be large enough to provide for an unobstructed passage of the gases. It does not appear that these rings affect the draft in the smoke stack, but it is quite possible that after the installation of the superheater the draft in the smoke stack may be reduced to such an extent as to weaken materially the action of the eddy rings.

Practice has shown that the installation of the rings involves certain difficulties. In the first place, the diameter of the tubes is not the same throughout and even in the same tube small differences are noticed in the free cross-section. Further, the data as to the internal diameter of the tubes

TABLE 2 TESTS OF EDDY RINGS ON TUG BOAT BOILERS

| | Tug Moritz | | Tug Otto | | Tug Ernst | |
|---|---|---|---|---|---|---|
| | No rings | Eddy rings | No rings | Eddy rings | No rings | Eddy rings |
| Duration of test, min. | 108 | 124 | 109 | 140 | 108 | 135 |
| Boiler pressure, atm. | 10 | 10 | 10 | 10 | 12 | 12 |
| Cut-off, per cent | 55 | 55 | 65 | 65 | 65 | 65 |
| Speed of engine, r.p.m. | 162 | 162 | 156 | 156 | 164 | 164 |
| Coal Consumption, total......kg. | 500 | 500 | 500 | 500 | 500 | 500 |
| lb. | 1102 | 1102 | 1102 | 1102 | 1102 | 1102 |
| Coal consumption per hour.....kg. | 277 | 241 | 275 | 214 | 277 | 222 |
| lb. | 609 | 530 | 605 | 470 | 609 | 488 |
| Temperature of flue gases, deg. cent. | 312 | 260 | 320 | 255 | 350 | 275 |
| fahr. | 593.6 | 500 | 608 | 491 | 662 | 527 |
| Trailer, ztn | 10000 | 10000 | 9500 | 11000 | 12800 | 13000 |
| SAVING IN COAL, % | .. | 12.9 | .. | 22.14 | .. | 20 |

are not always reliable and it has happened more than once that rings turned exactly to a supposed diameter of the tube, either did not go in at all or were so loose that they dropped into the firebox during the trip. This led to rejecting the direct insertion of the rings and adopting a different method. The rings are now turned somewhat smaller than the diameter of the tube, but each ring is held (Fig. A and B) by means of two flat iron bars, located along the axis of the tube in such a manner that the rings cannot then drop out. A series of rings therefore is put into each tube as a unit and can be quite easily withdrawn, for example if any repairs on the tubes have to be carried out.

This method of using withdrawable fire rings has proved to be very desirable in view of the ease of installation and for this very reason, such rings have a material advantage over the so-called retarders. Tests with these withdrawable rings have shown results practically similar to those with specially installed rigid rings. The author claims that eddy rings can be used to advantage also in feed water preheaters and air heaters of the Howden boiler installation. A figure in the text shows an air preheater for a modern boiler plant. In condensers, the rings can be applied only when the cooling water is pure, because otherwise, the deposits would rapidly reduce the free cross-section of the tube, but if the dimensions and arrangements of the rings have been properly selected, it is claimed that beneficial results can be obtained thereby. (*Betriebsergebnisse mit Wirbelringen in Feuerrohrschiffkesseln,* Forst, *Schiffbau,* vol. 16, no. 4, p. 72, November 25, 1914, 6 pp., 6 figs. *de*).

### Placzek Traveling Grate.

Description of a traveling grate essentially consisting of chain elements and intervening grate bars.

The main purpose of the new construction was to avoid as far as possible the rapid wear of the grate elements and to provide for an easy exchangeability of parts. Two guiding chains provide supports for the grate bars while the links of the chain carry the grate bar supports on which lie the grate bars themselves either longitudinally to or across the motion of the grate in such a manner that they may be easily removed when desired. In this way, the chain itself lying outside of the path of the grate proper is not affected directly by the heat of the furnace and is rather subject to a cooling by the air of combustion, which results in its wear being considerably longer. Further the grate bar elements can be shaped in any desired way and a grate surface can

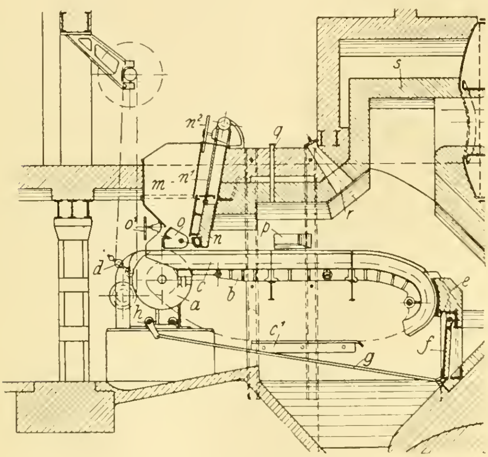



Fig. 5 Placzek Traveling Grate

be obtained so as not to be fully continuous. As a result of that, it is more uniformly and efficiently cooled by the air of combustion. In changing to a different kind of fuel, the economic combustion of which requires a different type of profile of the grate bars it is not necessary to replace the entire grate. All that has to be done is to put in a set of new bars of the desired profile, as the old and used up bars are being taken out.

The traveling grate of this new construction in which the separate grate bars, together with their bearers, can be so easily exchangeable that it is not necessary to have the entire grate removed, has been patented in Germany by Placzek. It is shown in Fig. 5. The grate as shown is 2650 mm. (104 in.) long and 1700 mm. (66.9 in.) wide. Essentially it consists of the two chains running right and left on rollers at $c$ $c^1$ which carry the grate bar bearers and through them the grate bars themselves. The guides $c$ are located in passages $b$ in the brick wall, while the chain itself, and by it the entire grate, is carried forward over the driving drum $a$. The rear guide is limited to the terminal section of the grate which is provided with a suitable curve. The drive of the grate by means of the driving drum is continuous and is effected by a worm gear drive running in an oil filled gear case on ball bearings with staged discs and belt tighteners $d$ in such a manner that the movement of the grate can be easily and quickly adjusted to three or more different speeds. The grate bar bearers located cross-wise are placed in the elements of the chain in such a manner that they can be easily withdrawn. The grate bars, selected so as to have the full path adapted to the kind of fuel used, have an essentially triangular cross section and should be placed on the bearers by one of the corners. In the upper part of the path of the grate they are, on account of their system of guiding, in such a position that they overlap one another and a practically closed surface is presented to the fuel. The part of the bar lying in front of the coal hopper end is just in this position, but when the rows of the grate bars are carried over the rear curved guide, the guides tilt around the bearers and then in the lower grate they hang downwards practically free so that they can be easily pulled out. (*Der Wanderrost System Placzek,* Pradel. *Zeits. für Dampfkessel*

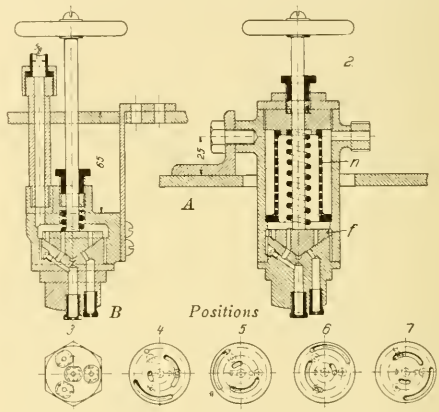



Fig. 6 Adjustable Burner for Liquid Fuel

*und Maschinenbetrieb,* vol. 37, no. 49, p. 523, December 4, 1914. 3 pp., 3 figs. *d*).

### Adjustable Burner for Liquid Fuel.

Description of an adjustable burner for liquid fuel, especially naphtha, of late widely used on Austrian ships.

The burner, as shown in figure A, permits very good regulation of fuel admission simultaneously with perfect atomization of the fuel which is made possible through the fact that the atomizing tip of the burner, provided with several nozzles, is equipped with a regulating device made in the shape of a rotary valve. According to the position given to it, this device either closes all the nozzles or permits the connection of a desired number of such nozzles with the fuel admission pipe.

The atomizing tip of the burner equipped with four atomizing nozzles is screwed into a casing of the burner. One of these nozzles is located in the center of the atomizing tip, while the others are disposed around it in a circle. The fuel passages leading to them open into a conical hollow opening in the atomizing tip in such a way that two of the fuel passage openings are located opposite one another at equal distance from the center of the working surface of that

hollow opening, while openings of the two other passages are disposed along circles of equal diameter and at distances of about 120 deg. from each other. (Compare Figure 6 A.)

On the atomizing tip is located a rotary valve which can be rotated by means of a spindle and hand-wheel and is pressed against the atomizing tip by a spring. In this rotary valve, there are three circular slots, two long ones extending over an angle of somewhat more than 90 deg., and a third slot, somewhat shorter. The radii of curvature of these slots correspond to the radii of the circles over which are located the openings of the fuel passages, so that in a proper position of the rotary valve, the shorter slot is located opposite the two inner passages, while the longer slots are opposite the outermost passage, the middle slot being placed over the middle position. In this case, the crude oil fuel passes through the admission pipe to the slot iu the fuel passage of the automizing tip standing in connection with the proper slots. As shown in Fig. B (4), the smallest slot of the tip is opposite the passage leading to the middle nozzle, while the other slots are still about 90 deg. away from the proper openings of the passage so that fuel is led in (5) only through the outer and middle nozzle which heat the upper part of the fire tubes particularly. With the further rotation through 90 deg. (6) the smallest slot covers the inner passage, while the rear end of the two upper slots are right opposite the corresponding passage openings, so that all the nozzles, with the exception of the central one, are in operation. Should the valve be turned through 90 deg. more (7) then all the slots come out of correspondence with the fuel passage openings and the fire in all the nozzles is put out. It is claimed that this type of burner in the Austrian marine has proved to be efficient. (*Einstellbarer Brenner für flüssige Brennstoffe, insbes. für Naphta, Der praktische Maschinen-Konstrukteur,* vol. 47, no. 51, p. 332, December 24, 1914, 2 pp., 2 figs., *d.*)

### Miscellanea

#### The Plumboxan Process for Producing Oxygen and Nitrogen from Atmospheric Air

The article describes the so-called Plumboxan process for the recovery of oxygen and nitrogen out of atmospheric air and the apparatus used for this purpose.

Plumboxan is a chemical compound representing the combination of a metallic plumbate salts of an alkali with a manganate, oxide of an alkali. For example, salts of a sodium basis and the following composition:

$$Na_2PbO_3 \quad Na_2MnO_4.$$

The idea of using a similar mixture is not entirely new and numerous tests in this direction have been made before, but when simple manganates are used they become soft during the period of evolution of oxygen, under the influence of high temperature and steam, and therefore lose more or less the porous state so essential for the evolution of a gas process; and as a result of that, the amount of gas given off gradually diminishes. As the author has found from his own experiments, this objectionable phenomenon is due to the formation or disassociation of hydrates of alkali which are evaporated through the action of the superheated steam. This secondary reaction destroys more and more the porous state of the material and the permanency of its chemical nature so that after a comparatively short time, it becomes necessary to introduce new material.

On the other hand, the manganates, on account of their rapid and easy formation, when a mixture of their components is heated in the air, are extremely convenient for use as extractors of oxygen from the air. All that was necessary, was to obviate the above described objectionable feature by proper means, and the author found that he could attain that by an addition of a plumbate salt. At the same time, he had previously been able to establish that in the presence of basic materials and a high temperature, it takes up oxygen from the basic oxygen and passes into orthoplumbate salts, which in their turn, under the influence of such hydratizing materials as steam, are converted into metaplumbates. Further, it is known that one of the general characteristics of plumbates is their ability to take up and give off basic oxides, and the author found that such would be just the right thing to take up the alkaloids from the manganates disassociated by water vapor and to reproduce them later on in a regenerating process. He actually found, on experimenting, that an addition of a metaplumbate and an alkali metal eliminated the vaporization of the alkali hydrate from the manganate and permitted the maintaining of the reaction material in a permanent working state.

The author describes in detail the respective chemical reactions and the construction of his apparatus. The Plumboxan process appears, from the description, to be quite simple. The air, after passing through cleaning chambers where it is freed from carbon dioxide, is driven by a blower, through a recuperator, into the main apparatus. After several minutes of regenerative action, the air current is shut off and practically simultaneously, the steam from a special boiler is admitted into the main apparatus where evolution of oxygen at once takes place. This oxygen is carried through the usual water seal system into a special gasometer.

As to the output obtained with this process, the data secured are only general. At 400 deg. cent. (752 deg. fahr.), in 5 minutes approximately 1000 ccm. of oxygen are obtained from 1 kg. of Plumboxan provided the material is in a good porous state. At 450 deg. cent. (842 deg. fahr.) 2000 ccm.; and at 500 deg. (932 deg. fahr.) 3000 ccm. and more are obtained. It is of interest also to notice that as the temperature rises, the oxygen becomes purer. Since the oxygen during the regenerative process is taken up from the air by the salt combination, nearly pure nitrogen is obtained as a by-product of the process. Further, the regeneration of Plumboxan by the air can be carried on at the same temperature as that of the evolution of oxygen.

The author discusses in considerable detail, the chemical part of the process and comes to the conclusion that catalysis plays an important part in this reaction. (*Das Plumboxan-Verfahren zur Gewinnung von Sauerstoff und Stickstoff aus der atmosphärischen Luft und die in der Versuchsanlage zuerst benützte Apparatur,* Professor Georg Kassner, *Zeits. für komprimierte und flüssige Gase,* vol. 16, nos. 8/9, p. 155, August-September 1914, 6 pp., 3 figs. *d*).

## ENGINEERING SOCIETIES

### AMERICAN WOOD PRESERVERS' ASSOCIATION

*Advance papers, Chicago meeting, January 1915*

The Bleeding and Swelling of Paving Blocks, Clyde H Teesdale

Sill Ties, F. J. Angier

Economical Use of Steam in Connection with Wood Preserving Plants, A. M. Lockett

Destruction of Timber by Marine Borers, E. S. Christiau.

Since marine borers do not thrive in foul water and prefer the uncontaminated water of the ocean, Hampton Roads offers an ideal environment for the growth of teredo and its kindred borers. In this connection, the author presents some data on the history of the Chesapeake and Ohio Pier No. 6, at Newport News, Va., on Hampton Roads, just below the mouth of the James River. It is interesting because in this case, timber treated with 12 lb. of Dead Oil per cubic foot has withstood the attacks of marine borers for 32 years, while timber not so treated lasts not more than two years and is sometimes destroyed after one summer season. Piles were treated and used in rebuilding that pier in 1883, the amount of the treatment required being that each of the piles absorbed 12 lb. of Dead Oil per cubic foot. One of the tests made to determine this was to bore each pile in six places and if any boring showed a penetration of less than 1½ in., the pile was rejected aud treated again. The specifications under which the oil was bought called for not less than 60 per cent of naphthaline. The author believes, however, that in the treatment of cross ties and bridge timbers, the naphthaline fraction may be lower, provided that the percentage of pitch is increased; in view of the difficulty of obtaining oil with more than 35 per cent of naphthaline, he has lately recommended 16 lb. of oil per cubic foot for marine work in Hampton Roads. (9 pp., 8 figs. *dh.*)

Additional Facts on Treated Ties, J. H. Waterman.

The author presents data on ties treated by various processes.

In inspecting ties treated by Full Cell creosote process in experimental tracks on the Burlington Railroad, he found that a number of cotton-wood ties treated by this process, although softwood, are giving most excellent service and are in as good condition as any other ties treated by this process on the experimental truck. Further, ties so treated do not rail-cut as badly as ties treated with zinc chloride.

As to ties treated with zinc chloride (the Burnettizing process), the author found in going over a number of the Santa Fe lines and lines in Western Kansas that ties treated with this process have given very good results and that practically all of them gave nine years' life before they were removed. On the Illinois Central Railroad, the author found that ties treated with zinc chloride in 1904 were giving much better service than ties treated in 1907, but does not explain why.

On the Chicago and Eastern Illinois Railroad, the author saw ties treated by the Wellhouse process (zinc, glue and tannin). On that line, red oak ties so treated were placed in track in 1900 and special dating nails were placed in each tie. By actual count, in June 1914, there were still remaining in the track about 75 per cent of the ties originally placed, thus giving them a 14 years' life; the author has even seen a number of red oak ties treated with the same process bearing dating nails of 1899—most of these ties being in a very good state of preservation.

Until the price of creosote was advanced, the Burlington Railroad treated their ties with the process known as the Card process (an emulsion of creosote and zinc). While a large number of ties so treated are laid in the experimental tracks of the Burlington Railroad, it is too early to draw any positive conclusions and one can only say that the ties treated with the creosote and zinc show less mechanical wear under the rails than those treated with straight zinc. It appears that the oil in the ties treated with the creosote and zinc is drawn to the surface and lubricates the tie under the rail which causes less rail cut and surface wear and prevents the tie from checking. (7 pp., *ed.*)

A Specification for a Coal Tar Creosote Solution, Herman von Schrenck and Alfred L. Kammerer.

The authors give a specification for a coal tar creosote solution, the necessity for which arose from the fact that during the past year it has become somewhat difficult to obtain the usual supply of high grade foreign creosote, and there have been increasing inquiries for the mixture of coal tar and creosote. The writers, therefore, in coöperation with the Barrett Manufacturing Company, made a number of tests to determine the distilling points, specific gravity and viscosity of the various mixtures, by which they obtained the data given in a table in the paper. Based on this and similar determinations, they gave the following specification which is not regarded as final but only as an attempt to describe as briefly as possible an oil made up of coal tar and creosote with a certain percentage of coal tar:

The oil shall be a pure coal-tar product, consisting only of coal-tar distillates and oils obtained by the filtration of coal tar. It shall contain no admixture of crude tar. Water shall not exceed 2 per cent. Specific gravity at 38 deg. cent. shall not be less than 1.06 or more than 1.10. Matter insoluble on hot extraction with benzole shall not exceed 2 per cent. Viscosity (Engler) at 82.3 deg. cent. (180 deg. fahr.) shall not be more than 59 for 200 c.c. No variation above 59 seconds shall be allowed. On distillation by the standard method of the A.R.E.A., it shall yield the following fractions, based on dry oil: Not more than 1 per cent at 170 deg. cent.; not more than 5 per cent at 210 deg. cent.; not more than 30 per cent at 235 deg. cent. The residue at 355 deg. cent. shall not exceed 26 per cent. (4 pp., *p.*)

## CENTRAL RAILWAY CLUB

*Official Proceedings, vol. 22, no. 5, November 1914, New York City*

Painting of Steel Cars and Locomotive Equipment, Milton L. Sims.

The methods of painting equipment of wooden construction would not be suitable for steel and the introduction of all steel equipment required the development of new methods based on an intimate acquaintance with paint pigments and vehicles.

The preparation of a steel coach for painting is of vital importance and demands close attention. It should never be left to inexperienced help and must be done thoroughly,

as the absolute removal of all scale, grease and corrosion is necessary before any protective coatings should be applied. Properly selected paint pigments combined with the proper vehicles will prevent the starting of corrosion, but the idea that paint coatings will stop corrosion when it has once started, is not correct. There are several methods for removing rust from steel, but the safest and most economical is sand blast for the outside of cars, while for the interior of a steel car, the speaker recommended the use of raw linseed oil and benzine or gasoline, in the proportion of one part of oil to two parts of benzine, applied with a brush and rubbed down with emery cloth or paper. The sheet steel used on the interior of cars is much lighter in weight and finer in texture and does not need sand blasting to obtain excellent results. After the rubbing down is completed, the surface should be washed with gasoline and wiped dry with rags or waste. It is then ready for the priming coat, which, in all cases, should be applied as soon as possible after the surface has been cleaned, especially in regard to the outside surfaces where the sand blasting process has been used, because when the atmosphere is damp or the humidity is heavy, corrosion will start up again in a few hours. Great care should be taken also to prevent the handling of the surface with naked hands.

The priming coat is very important and too much care cannot be exercised to see that it is done thoroughly, brushed out evenly and every bolt-head and joint coated perfectly, using suitable brushes for the purpose. The solid through trains, running from the ice and snow of the North to the tropical climate of the South, are especially liable to influences producing cracking and disintegration of paint and varnish films, on steel cars, much more than wooden ones. When the priming coat has dried sufficiently, the next step is to harden putty and to glaze coat over all the rough places, in which case the second coat or brush surfacer is used, which is designed to fit with the priming coat. This material must always be finely ground, and work and spread easily over the large surfaces. It must dry hard but elastic.

The next step is to apply a much heavier bodied surfacing material, which is then knifed off, leaving a very smooth surface, which requires much less rubbing to make it ready for the color coats. The old method of using block pumice stone and water is dispensed with and a more modern and safer method of rubbing the surfaces down smooth by using raw linseed oil and benzine in equal parts on emery cloth and then washing or wiping the surfaces off with clear benzine or gasoline on rags or waste. This method of surfacing does away with all danger from moisture and prevents the starting up of corrosion where sharp edges or bolt heads may be cut through the metal.

The paper describes further the application of body color, interior finish, the painting of floors, roofs, trucks and platforms and gives also the following schedules for painting the exterior of steel passenger coaches and locomotives:

SCHEDULE FOR PAINTING EXTERIOR OF PASSENGER COACHES

| | | |
|---|---|---|
| 1st | Day | Apply priming coat. |
| 2nd | " | Harden putty and glaze all rough and uneven parts of surface. |
| 3rd | " | Apply coat of brushing surfacer. |
| 4th | " | Apply coat of knifing surfacer. |
| 5th | " | Rub out with emery cloth, using half and half raw linseed oil and benzine, instead of block pumice stone and water. |
| 6th | " | Apply first coat of car body color enamel. |
| 7th | " | (If Sunday) drying. |
| 8th | " | Apply second coat of car body color. |
| 9th | " | Stripe and letter. |
| 10th | " | Apply first coat durable outside finishing varnish. |
| 11th | " | Drying. |
| 12th | " | Apply second coat of durable outside finishing varnish. |
| 13th | " | Car is completed. |

SCHEDULE FOR PAINTING A LOCOMOTIVE

| | | |
|---|---|---|
| 1st | Day | Apply priming coat of special locomotive primer. |
| 2nd | " | Harden putty and glaze coat all rough and uneven surfaces. (This does not apply to trucks, frame work, etc.) |
| 3rd | " | Apply brushing and knifing surfacer to water tank or tender, cab, steam dome, sand box, etc. |
| 4th | " | Rub out surface with emery cloth, using half and half raw linseed oil and benzine. Wipe off dry with rags or waste and clear benzine, being careful not to use too much benzine. Follow up with coat of black enamel. On best work, a coat of flat black is applied over all surfaces, except trucks, frames, etc., before the black enamel coat is applied. |
| 5th | " | Letter and finish with a coat of durable locomotive finishing varnish. |

Shorter and quicker methods are not reliable or recommended, except for re-painting and repair work. (30 pp., 3 figs. *pd.*)

## CORPS OF ENGINEERS, UNITED STATES ARMY

*Professional Memoirs, vol. 7, no. 31, January-February 1915, Washington Barracks, D. C.*

Action of Water in Locks of the Panama Canal, Col. H. F. Hodges
Percolation and Upward Pressure of Water, Capt. W. A. Mitchell (abstracted)
The Huai River Conservancy Project

PERCOLATION AND UPWARD PRESSURE OF WATER. Capt. W. A. Mitchell.

The paper considers the action of percolation and upward water pressure is as far as it affects the design of dams, and is to a large extent based on experimental work.

Very little information has been obtained so far as to upward pressure, and although it has been known for a long time that some provision for it was necessary, no accurate allowance has been made in the past. The author investigated three fundamental subjects—adhesion, percolation and upward water pressure, as affecting the design of dams and locks, mainly on the basis of experimental work done for this particular purpose by the Ohio River Board and others. The article, though of great interest, is too long to be fully abstracted and only the author's conclusions are here reproduced.

Little or no allowance can safely be made for adhesion of concrete to concrete or of concrete to rock.

Water pressure is transmitted through concrete, though quite slowly. If allowed free exit, this pressure is practically negligible.

Water pressure is transmitted through joints between con-

crete and concrete, and is transmitted more freely than through solid concrete. The water is transmitted quite slowly and if allowed free exit, the pressure is practically negligible.

Water pressure is transmitted through joints between concrete and rock. This is generally transmitted more freely than through joints between concrete and concrete. The amount varies with different rocks. The water is transmitted quite slowly in general and if allowed free exit, the pressure is practically negligible in good rock without cracks or fissures.

Water travels in small veins in the joints between concrete and concrete, and between concrete and rock. If allowed free exit, the pressure varies irregularly between upper and lower pools. If the exit is closed, the pressure quickly becomes that of upper pool, and water rises in test holes to level of upper pool as soon as enough water has passed through the veins to fill the test holes.

The amount of space of these small veins, that is, the area of upward water pressure, varies from nearly zero in excellent granite foundations to 50 per cent or more in rotten shale. It is practically impossible to calculate this.

Water pressure is transmitted more or less freely through washed sand, gravel aggregate, and washed river gravel and hardly at all through alluvial soil.

Puddled alluvial soil has practically no water pressure, if there are any drains, but such soil quickly disintegrates with a running leak.

With a material such as alluvial soil, which offers such a great resistance to percolation as practically to prevent it, a very small number of relief holes in the slab would be sufficient to eliminate almost the upward water pressure, provided, of course, that the material were such that only percolation and no erosion would take place.

With a material offering so great a resistance to percolation as washed sand, a very small number of relief holes would greatly reduce the upward water pressure when there is no outlet at the toe of the slab.

With a slab having a free exit for water at the toe, and a row of sheet piles at the heel, the upward water pressure varies from one-third the head at the heel to one-fourth the head at the toe.

Gravel aggregate offers less resistance to percolation than the river sand, and more than the river gravel. Hence, for the same reduction of upward water pressure when there is no outlet at the toe of the slab, more relief holes will be needed than for the sand and less than for the washed gravel.

For a slab having free exit for water at the toe and a row of sheet piles at the heel, the upward water pressure varies from one-sixteenth the head at the heel to one-fortieth the head at the toe.

In a material offering such a small resistance to percolation as washed gravel, a large number of relief holes in the slab will be necessary to reduce materially the upward water pressure when there is no outlet at the toe of the slab.

With an outlet for water at the toe of the slab and a row of sheet piles at the heel, the upward water pressure varies from full head at the heel to about one-third the head at the toe.

The pressure of water with free exit, transmitted through sand, washed gravel, or gravel aggregate, is diminished greatly on entrance and more slowly, but surely, diminished along the line of travel.

Full upward pressure of water, without free exit, is transmitted quickly through washed gravel, and less quickly through gravel aggregate and sand.

Water percolates (very slowly) through concrete and rock.

There is very little percolation through alluvial soil.

Water percolates more or less freely through sand, gravel aggregate, and washed gravel.

Water creates "boils" at the toe of the foundation after the relation of head to length of travel (percolation factor) becomes a certain amount, varying for different materials. This condition is dangerous to the foundation when the velocity of exit is sufficient to carry away with it the material of the foundation. It is generally best to make this percolation factor so great that there will be no such boils.

If the percolation factor is too small (varies for different materials) the material under the foundation will blow out and the foundation will fall in. With alluvial soil, this blow-out comes with little or no previous warning by boils. (50 pp., 34 figs. eA).

## INSTITUTION OF CIVIL ENGINEERS

*Advance paper, session of 1914-1915, no. 2*

Tests of Reinforced Concrete Structures on the Great Central Railway, J. B. Ball (abstracted)

Corrosion of Steel Wharves at Kowloon, S. H. Ellis (abstracted)

Concreting in Freezing Weather, and the Effect of Frost upon Concrete, John Hammersley-Heenan

Tests of Reinforced Concrete Structures on the Great Central Railway, J. B. Hall.

Data of tests of reinforced concrete structures on the Great Central Railway, such as an overbridge, a bridge carrying a new road and tramway, four high level railway bridges, and foundations and pits for engine shed.

In the case of the overbridge, the entire superstructure is reinforced with round bars on the Hennebique system; the abutments at each end are of mass concrete but the piers are braced and reinforced. Both tensile and compressive reinforcements were used in all the beams, the percentage of reinforcement in the main girders being exceptionally high on account of the area available in the compression flange. The bridge was tested with a dead load of 1 cwt. per square foot and a rolling load of two 16 ton traction engines, each hauling a lorry loaded with pig iron to a weight of 32 tons, or a total moving load of 96 tons. In all cases, the recovery was complete after the load was removed. The working stresses were limited to 700 lb. per sq. in. maximum compressive stress on the concrete, and 16,000 lb. per sq. in. tensile stress on the reinforcement.

In the reinforced concrete bridge carrying a road and a tramway for the Grimsby District Light Railway, the percentage of reinforcement ranges from 0.60 per cent in the cross beams to 4.67 per cent in the outer main beams of the longer span. The bridge was tested with two moving tramcars and no appreciable deflection was reported on any of the beams. It was designed to allow for the passage of two 40 ton boiler-trollies drawn by a 5 ton traction engine, the portion of the bridge not covered by moving loads being loaded with 1 cwt. per square foot. In computing the stress, the various members were taken as being freely supported

and no allowance was made for the continuity of the beams, or for the fixity of the ends, the allowable working stress being the same as in the case of the previous bridge.

In the reinforced concrete foundations and pits for the engine shed at Inningham dock, the work consists of a reinforced concrete raft so spread that the load upon the ground nowhere exceeds 10 cwt. per square foot, and the engine pits form part of the raft. Reinforced tie beams are provided every 60 ft. between the pits, and Kahn bars are used throughout in the reinforcements of this work. (4 pp. *d*).

Corrosion of Steel Wharves at Kowloon, S. H. Ellis.

Description of steel wharves at Kowloon, Hong Kong Harbor, British possessions in China, and the corrosion of same.

In 1906, in connection with the reconstruction of a wharf an examination was made of some steel piles, which had been in place for about four years, and they were found to be corroded in a curious manner. Any steel immersed in sea water at Hong Kong becomes quickly coated with barnacles and other shell-fish, and with a dense vegetable growth, particularly very near the surface of the water down to 15 ft. or so below it. It has been an accepted theory that this growth protects the metal and prevents rusting, but when the growth which had been scraped away from the pile was examined, it was found that a large number of pits had formed in the surface of the steel varying in size up to $1\frac{1}{4}$ in. in diameter and 3 in. deep. They were found full of a black carbonaceous powder, which was found also in a thin layer on the surface of the unpitted steel and, on exposure to the air turned to a dark red color. On analysis, it was found to be sulphide of iron and its change of color was due to oxidation. Apparently some particular shell-fish or marine growth attached to the piles produces large quantities of sulphide of hydrogen when dead and decayed, and this sulphide of hydrogen attacks the metal. It is evident that when once this process is started, the deposit of sulphide favors more rapid corrosion beneath it. The destructive effects of this kind appear to be confined to the part between low water level and 15 ft. below it, the zone of the worst corrosion extending from 5 ft. to 10 ft. below low water level.

It was eventually decided to incase the whole of the new structure in concrete and have the other wharves bare steel painted with anticorrosive composition on erection. Since this was done the superstructure and the piles above low water level have been scraped and painted annually and the steel has been kept in fair condition with no mark of deterioration except once, when a longer period than twelve months was allowed to elapse between recoatings. The yearly cost of maintenance is about £100 for a total deck area of 34,000 sq. ft. Two years after completion, pitting had commenced on the under water surface of the piles, the construction coating of paint having then almost disappeared and a thick layer of shells and marine growth had become attached to the metal.

The author describes in detail the method used in incasing the piles with concrete, a minimum cover of $2\frac{1}{2}$ in. of Portland cement concrete of standard quality being provided to the steel throughout. After the whole of the work had been completed about a year, and the bulk of it for about two years, the author made an inspection of the wharf and was unable to detect any sign of deterioration on the surface, but he did not cut into the concrete. Three years later obvious indications of corrosion within became apparent on the surface of the concrete and a thorough examination of the whole structure revealed that above high water level corrosion appeared to have gone on almost unchecked by the presence of the concrete covering, and a thickness of about 1/16 in. of rust scale was found on all the steel members in this zone on their under and outer sides.

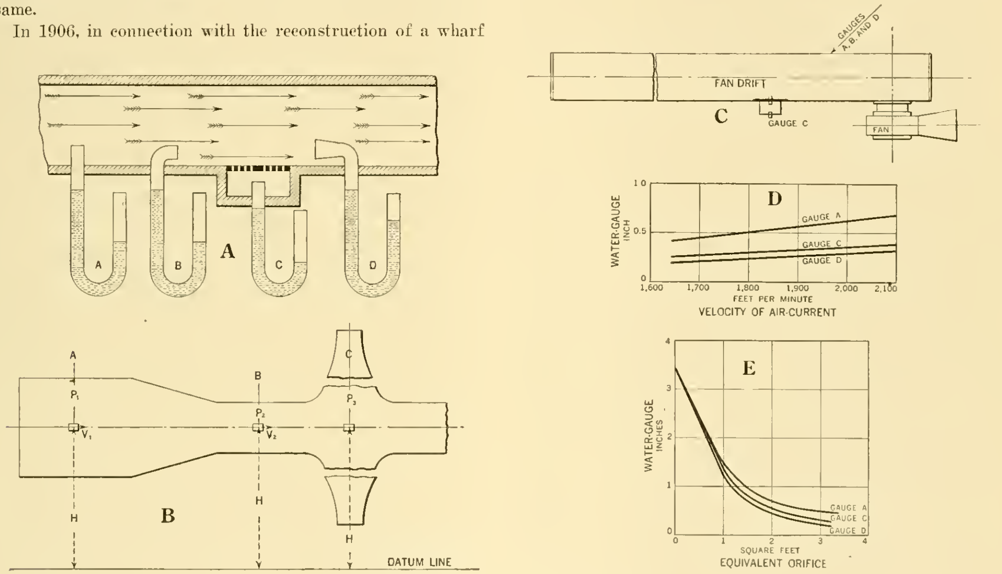



Fig. 7 Fan Test Curves and Water Gages

The author concludes that while steel protected by concrete has little or no tendency to corrode if it becomes thoroughly wet twice in the twenty-four years, yet when it is continually exposed to air damp from the evaporation of sea water, especially in a tropical climate, some other external coating must be sought, either as an addition to the concrete or in place of it. Curiously enough the corrosive effects of damp salt air appear to be limited to a zone immediately above the surface of the water. Steel work, both exposed and embedded in concrete, in warehouses on the same property has not been found to be affected.

## INSTITUTION OF MINING ENGINEERS

*Transactions, vol. 48, part 1, November 1914, London.*

The Rosehall Signal-Indicator, James Black
The Testing of Fans, with Special Reference to the Measurement of Pressure, Thomas Bryson (abstracted)
Substitutes for Wooden Supports in Coal Mines
Tests on False (or Split) Links for Cut-Chain Braes, John T. Wight

The Testing of Fans, with Special Reference to the Measurement of Pressure, Thomas Bryson.

Discussion of the question of reliability of fan tests and determination of various factors in the expression of mechanical efficiency with special respect to the exact determination of the height of the water gage.

The writer bases his specification for a water gage on the principle of conservation of energy as applied to measurement of pressure and proceeds to the discussion of the position and form of the water gage. While it is generally agreed that the water gage should, in addition to being placed at the entrance to the fan, be measured also at the ear of the fan, there is nothing unanimous with regard to its precise position. If *D*, Fig. 7A, be the correct form, it may be placed anywhere near the fan—even in the ear of the fan, but if *C* be used, it may be most conveniently placed near the ear of the fan on the wall of the drift. If the gage be placed in the ear of the fan, error is bound to arise from varying velocities, due to eddying currents, but if a gage of the form *C* be placed on the wall of the drift near the fan, and separated from the drift by a partition in which there is a capillary connection, it is most likely that the pressure registered will be effected by air currents, since the interior of the box will be a zone of reduced pressure in which there would be no appreciable movement of the air. The condition of the air in the box will be quite the same as that of the air at section *C* in the drift (Fig. B); consequently, a gage of the ordinary form, fitted to such a box, would register exhaustion only.

The writer has recently made some experiments to test his conclusions with regard to the various forms of water gages. The following data are typical of the results obtained: Experiment No. 1 was carried out for the purpose of determining what pressures would be registered by gages of the forms *A, B, C* and *D*, attached to the fan drift, when no air was allowed to pass through the fan drift, it being closed at the end. Relative position of the fan, fan drift and gage are shown in Fig. C. The results obtained after a number of speeds of the fan are shown in a table. Another series of experiments was made to establish a relationship between gages of the forms *A, C* and *D* for the various velocities of the air passing the drift. A constant opening was maintained at the end of the drift, the change of velocity being obtained by altering the speed of the ventilator. The results of this test can be seen from the curves in Fig. D. In the third series of tests, pressures were registered over a greater range of velocities than in the preceding series and the opening at the end of the drift varied, in order to obtain a series of "equivalent orifices." The results from this experiment are given in the original article in the form of a table, and are shown here by the curves in Fig. E.

From these tests, it appeared that at least three forms of the tube terminations *A, B* and *D*, were not scientifically correct. It was shown that the value of $P_3$ (Fig. B) at section *C* would be greater than either $P_1$ or $P_2$ at sections *A* and *B* respectively. Further, pressure registered by a water gage situated in the zone of reduced pressure, separated from the fan drift by a partition having a capillary connection in it, is greater than the section registered by a Pitot tube. If, however, the velocities are small, there is little difference between the readings given by *C* and *D*, but there is considerable difference between them at high velocities such as 960 revolutions of the fan per minute, and velocity of air 1,600 ft. per minute.

In the discussion which followed, Wm. Davidson of Glasgow stated that recently he had had the experience of doubling the quantity of air in a mine by putting down a larger fan and when the fan was tested, in the first instance, difficulty was experienced in finding the proper water gage. No matter how the end of the tube was placed in the fan drift, there were different readings, indicating that something was wrong with the method. A method similar to that described in the above paper, however, was the only one tried. A steady reading was obtained and it was from that reading that the figures were worked out for the new fan. In building a fan drift for the new ventilator, a small manhole was inserted in the side with a steel door, having very small perforations. The end of the water gage was turned into that. The results from the new fan were very satisfactory. (6 pp., 5 figs. *e.*)

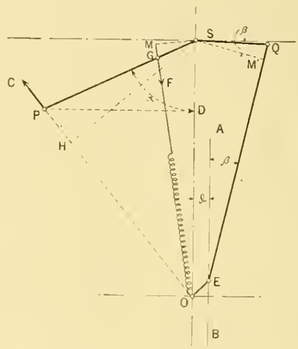



Fig. 8 Diagram of a Shaft Governor

## KYOTO IMPERIAL UNIVERSITY, COLLEGE OF ENGINEERING

*Memoirs, vol. 1, no. 1, August 1914, Kyoto, Japan*

Disturbing Actions of a Shaft Governor, Genjiro Hamabe.

The paper is devoted to a consideration of the disturbing actions of a shaft governor applied to a steam engine as its

speed regulator. It reports an investigation of the laws of these disturbing motions, considers the statical conditions of the governor and gives a method of designing it in connection therewith.

In the case of a conical pendulum governor, the forces at the sleeve required for overcoming the resistance of the regulating gear when a movement of the sleeve is commenced, may be regarded as constant in magnitude. The case is quite different in a shaft governor. Most shaft governors in practical use are attached to the fly-wheel, the eccentric disk being held in position by the governor and on this account, a comparatively large amount of the resistance of the valve gear continually reacts on the governor. Fluctuating and reversing periodically, according to the position of the crank, these forces cause the pendulum of the governor to vibrate about its position of equilibrium and this vibratory motion may cause a false distribution of steam. Further, when the load on the engine is altered, the relative configuration of the governor changes accordingly and the pendulum moves from one position of equilibrium to another.

On account of the inertia of the pendulum and the parts connected therewith, this change of configuration is sometimes accompanied by a number of vibratory motions which cause a serious disturbance of steam distribution. Fig. 8 is a diagrammatic sketch of a shaft governor showing about one-half of the governor. It is attached to and rotates as usual with the crank shaft *O*, consisting of a pair of pendulums arranged symmetrically with respect to *O*, with its fulcrum at *S* and its center of gravity at *P*; a spring *F* attached at *G* and passing through *O* connects the pendulums. There is a centrifugal force *C* at each pendulum so as to throw it out against the force of the spring *F*. The pendulum has a lever *SQ* on the opposite side of *S* and the end *Q* of this lever is connected with the eccentric center *E* by means of a rod *QE*. In order to keep the lead of the valve constant, the eccentric center is assumed to be guided so as to move along a straight line *AB*, perpendicular to the center line of the crank. After the engine is unloaded, either suddenly or gradually, the speed of the engine increases, the pendulum flies out owing to the corresponding increase of the centrifugal force and the steam is cut off earlier than would have been otherwise the case.

If there were no vibratory motions of the governor, the pendulum would be at rest with respect to the flywheel in a steady working condition of the engine; consequently all moments of force, acting at several points of the pendulum would be in equilibrium and for the equilibrium of the pendulum about this fulcrum *S*, the following three moments must form a balancing set; the moment of the centrifugal force of the pendulum acting clockwise; the moment of force of the spring acting counter-clockwise and the moment of the mean reacting force of the valve gear acting counter-clockwise. The first moment depends on the angular velocity and the position of the pendulum: the second and third moments, on the position of the pendulum only. The author gives equations for the determination of these three moments as well as an equation of the state of equilibrium of the governor, and from this equation can be found the values of the moment of centrifugal force of the pendulum at different positions and the characteristic curve of the governor can be drawn. The irregularity of the governor can be found from the curve. Conversely, assuming the value of principal irregularity of the governor, we can determine the dimensions of the governor spring from the equation.

The author gives examples of the application of these equations, such as that of a vertical single cylinder 10 in. x 10 in. fitted with a piston valve 4.33 in. in diameter, running at 240 r.p.m., under a pressure of 6 atmospheres absolute and regulated by a shaft governor mounted on the crank shaft. He goes through the entire calculation and gives the characteristic curves of the governors which, under certain limitations, would be used on such an engine. This part of the article is not suitable for abstracting.

He proceeds then to an investigation of the vibration of the pendulum caused by periodic changes of the reacting forces of the valve gear, and treats the subject in a strictly mathematical manner. From the results of calculation he finds that the vibration of the pendulum caused by the reacting forces of the valve gear rises to a degree which is inadmissible in a regulator. If one tries, as with the conical governor, to make the "energy" so great that reacting forces may be inappreciable, a disproportionately heavier governor is necessitated and we have to remain content with the governor accompanied by vibrations which are damped in practice by frictional resistance at pins or at knife edges which was not taken into account in the deduction of the equation of motion; or some device must be perfected whereby to suppress these vibrations. Since in a conical governor the chief source of vibrations is the unsteadiness due to the finite mass of the flywheel, they may be removed by fulfilling the condition that the insensibility of the governor should not be less than the unsteadiness of the flywheel, but in a shaft governor, which is a pure spring governor, the vibrations are caused by the reacting forces as well as by the influence of the unsteadiness of the flywheel and meeting only the latter condition, would not sufficiently remedy the evil. To obviate this, a shaft governor is often provided with a dash pot or oil brake.

The author next investigates the mechanical motion of the pendulum when the load on the engine changes and finds the equations which show this. In several examples, he shows the manner in which the governors approach their new position of equilibrium, some of them coming to it sooner or later with the approaching motion accompanied or not by some oscillation, but without any over regulation at all, while in all other cases, the governors make over regulation in different degrees, all, however, come practically to rest after some interval of time in the new position of equilibrium. On the whole, the author concludes that the governors which are found by means of their characteristic curves to be stable, do not necessarily come to their new position of equilibrium. In other words, a governor not fulfilling the conditions established by one of the equations found by the author and having no constant friction is of an unsteady character, while some governors may be defective on account of over regulation or hunting. Moreover, if a governor be constructed so as to obviate these defects, too steady a governor may result, which requires a longer time for its displacement; such a governor is again unfit for practical use.

An interesting part of the above paper not presented in the abstract is the mathematical treatment of the subject and the characteristic curves of the governors reproduced in the paper.

## NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

*Transactions, vol. 30, part 6, December 1914, Newcastle-on-Tyne.*

A Review of the Progress in the Marine Steam Engine on the North-East Coast During the Last Fifteen Years, A. C. Ross

Charging of Two-Cycle Engines, Professor B. Hopkinson (abstracted)

A New Type of Internal Combustion Engine, H. F. Fullagar (abstracted)

### The Charging of Two-Cycle Internal Combustion Engines, B. Hopkinson.

The paper discusses the subject of charging of two-cycle internal combustion engines and takes up the effect of stratification on the performance of the engine. It includes also tests on the Fullagar engine.

The performance of two-cycle internal combustion engines is determined very largely by the efficiency of the process of charging. In view of the very short time given for replacing the gases of combustion by a fresh charge, some mixing in-

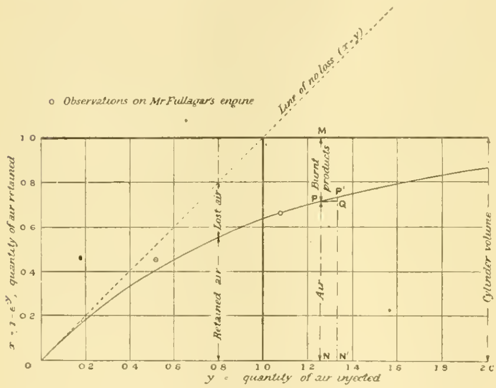



Fig. 9 Charging Curves of Fullagar Engine

evitably takes place and some of the fresh charge or of the scavenger air passes away to the exhaust and is wasted. The waste of fuel affects the economy of the engine as well as the size of the charging pumps, which must be large enough to deliver the whole charge of gas and air, including that which is wasted.

The author stated that he was struck by the almost complete absence of data of general application on which to base, in the case of a new design, the calculation of the size of pumps required to give a certain mean pressure and a prediction of the economy which may be expected. Little or nothing has been published as to the amount of the loss to exhaust which occurs in exhausting engines, and there is no theory to guide designers in the use of such data as exist on this point or may become available.

In the course of the charging process, for each unit of volume of air or mixture which enters at the inlet, an equal volume of the gas near to the exhaust ports will be driven out through those ports. The gas will consist partly of burned products and partly of air which is mixed with the products. Denote by $z$, the proportion of air by volume contained in the exhaust gases at the point close to the ports at any stage of the charging ($z$ is not the volumetric proportion determined by ordinary analysis but the volume reckoned at atmospheric pressure and at the temperature of the air as it comes in, contained in a cubic foot, the balance of $1-z$ consisting of burned products from the previous explosion, whose volume is for this purpose reckoned at the temperature of those products before charging began). Obviously $z$ will increase from zero as the charging goes on and will approach but never reach the value unity. The total amount of air lost in charging will be equal to the volume delivered, $z$, multiplied by the average value of $z$ and is readily calculable if this quantity is known at every stage. The mass of air retained in the cylinder is equal to $y$ minus the loss, and this will be denoted by $x$.

Two cases admit of very simple treatment. The first is the ideal case of perfect stratification where the air simply drives the burnt gases before it without mixing with them at all and there is no loss at all until the amount of air exceeds the cylinder volume,—a condition which is never even approached in practice; and the second case is more nearly what actually happens,—instead of complete stratification there is no stratification at all, mixing being so complete that the cylinder contents are at every instant of uniform composition throughout. Here the quantity $z$ represeuts not only the proportion of air in the gas which is going into the exhaust at any stage, but also the proportion then present in the cylinder as a whole. For the sake of convenience, as unit of volume, is taken the whole of the cylinder volume of air maintained in the cylinder, which also represents the proportion of air in the whole cylinder contents so that in the case now under consideration $z$ equals $x$. In Fig. 9, $x$ is plotted against $y$, the amount (in cylinder volume) of air which has been injected. When the amount $ON$ has been injected, the air present in the cylinder is $PN$, the remainder $PN$ being the burned products. The effect of adding the further dose of air $NN'$ is to expel at the exhaust, the quantity of air $\frac{PN}{MN} \times NN'$. The balance remains in the cylinder, increasing the quantity of air there by $P'Q = \frac{PM}{MN} \times NN'$, and the curve can be constructed in this way step by step. It is an exponential curve, whose slope at any point is equal to the ordinate $PM$. The relation between $x$ and $y$ is $X = 1 - e^{y}$. In short stroke Diesel engines with valves in the cylinder cover, the mixing is probably fairly complete. In engines having relatively longer cylinders, there is some stratification of the cylinder, but even there, not very much.

The main tests of the author were made on the Fullagar engine (described in the next abstract). In it, the air ports communicated with a large receiver to which air was delivered by an electrically driven fan. Coal gas was used in these trials and was admitted by a piston valve at the center of the cylinder, being delivered at high pressure by a reciprocating pump. For the verification of the formula above given were required the accurate measurements of, first, the total capacity of air delivered to the engine per minute and, second, the proportion of that air retained in the cylinder. To measure the quantity of air, a diaphragm with a circular hole was inserted in the air delivery pipe between the fan and the engine and the drop of pressure was measured by

means of a water gage. The diameter of the air pipe was 18 in.; that of the hole in the diaphragm 9 in. The current of air through the diaphragm was nearly uniform because of the pulsations of the engine being nearly damped out by the large air receiver. The velocity of the air through the hole was calculated according to the usual formula, assuming 0.62 as the coefficient of discharge. The author believes that the quantity of air delivered to the engine was probably determined correctly within three per cent; the coal gas was also metered.

For determining the proportion of air retained, samples were taken of the contents of all four cylinders and analyzed. After absorbing the $CO_2$ the combustion of the residue was completed over palladium and the further yield of $CO_2$ obtained. The total $CO_2$ gave the proportion of coal gas to air in the cylinder contents. Simultaneous analyses of the exhaust gases gave the proportion of coal gas to air delivered to the engine, a check being obtained by estimating the oxygen in the exhaust and in the cylinder contents. The results obtained showed that there is a rough agreement between the calculated and measured figures—sufficient at any rate to justify the use of the simple supposition of complete mixing as the first approximation of what occurs. On the other hand, the deviation with smaller amounts of air is too great to be ascribed to errors of observation, the observed loss of air being only about two-thirds of the calculated loss which shows that there are disturbing factors which must be taken into accouut as corrections to this simple theory. One of such factors is the effect of stratification, the portions near the exhaust ports being poorer in air and richer in burned products than the average. In addition to that, there is also in all cases some throttling in the exhaust ports and exhaust pipe as well as inertia effects in the exhaust pipe in consequence of which the pressure in the cylinder varies during the admission period.

In the discussion which followed and which referred to both papers (Professor Hopkinson's and Mr. Fullagar's), Mr. J. W. B. Stokes pointed out that the waste of charging air is a field which cannot very well be avoided. If it were attempted to cut down this charge of air to the minimum quantity or to have no loss at all,—at any rate through the exhaust ports,—there would be a very great danger of some of the fresh gas making contact with the products of combustion, which would lead to a back fire. Therefore, for the safe working of the engine, scavenging becomes necessary. He described an experiment he tried with an engine in which the air loss was cut down to the lowest possible figure,—in fact, there was no scavenging air sent forward at all, but it was touch and go with explosions at the right moment of preignition. The speaker further objected to the measurement of air in Professor Hopkinson's experiment by means of a diaphragm, as a possible error might be nearer 30 per cent than 3 per cent. In regard to the discontinuance of building the Oechelhauser engines by William Beardmore & Sons Company, Ltd., of Glasgow, which attracted considerable attention in England, the speaker, who is connected with that firm, stated that the reason for this was not that the engine was unreliable but that it cost too much to build it.

Alan E. L. Chorlton expressed his disappointment at the fact that Professor Hopkinson did not give any particular data taken from engines actually in use. He objected also to the statement that the imperfection of the charging process was probably in a large measure responsible for the fact that 2-stroke engines have been unable to compete successfully in small sizes, with the 4-stroke cycle, and believes that there are not sufficient data available to make such a broad statement. (30 pp., 6 figs. *eA*).

### A New Type of Internal Combustion Engine, H. F. Fullagar.

Description, somewhat incomplete, of the construction and operation of the Fullagar gas engine.

The Fullagar engine has been designed to overcome the

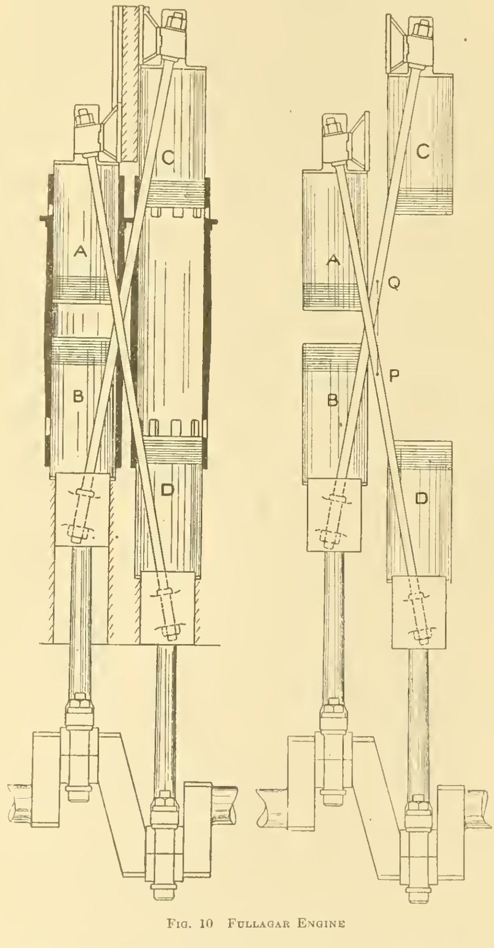



Fig. 10 Fullagar Engine

difficulties which are claimed to be in the way of increasing the size of gas engines: first, that the heat per unit of surface radiated by the flame to the cylinder walls increases with the size of the cylinder, while the thickness of the metal through which this heat has to reach the cooling water also increases; second, that the weight per h.p. increases with the size of the cylinder, and third, that the useless forces are called into play (useless in that they are either stationary

and do no work or even produce negative work). The Fullagar engine shown in Figs. 10 A and B, uses as a unit two open-ended cylinders, side by side, each with two pistons, and rigidly connects $A$ to $D$ and $C$ to $B$ by means of pairs of oblique rods external to the cylinder.

The action of the engine is as follows: when an explosion takes place between $A$ and $B$, it drives $B$ down and $A$ up, drawing up $D$ by the oblique rods, and giving, through the two connecting rods, two equal and opposite impulses to the cranks. The obliquity of the rods is small,—less than the obliquity of the connecting rods, so that the friction is actually less than would be the case if each piston had its own crank and connecting rods, and the mechanical efficiency of the engine is high. At the end of their strokes, the pistons uncover inlet and exhaust ports in the cylinder walls,—the engine working on the two-stroke cycle. Air is supplied to the cylinder by low pressure air pumps which can be driven from the engine by side levers in the ordinary way. In engines of the light high speed type, the upper cross-heads and guides are formed to act as air pumps, thus effecting a further saving of space and width. Stationary engines will usually comprise two units, making four cylinders, while more cylinders may be added for very large powers or where the height is limited.

With this construction, it is claimed that useless forces are avoided or at least greatly reduced. There are no cylinder covers nor any high pressure joints in the engine; no vertical stresses on the framing of the engine at all, the pressure of the explosion being entirely taken between the steel bars shown in Fig. B, the cross-head, oblique rods, connecting rods and crank shaft, and only the secondary reactions of the slippers, from 1/5 to 1/20 of the explosion forces, reach the framing of the engine in a horizontal direction.

The fluid pressure in each cylinder acts at every moment equally on the two cranks and the main bearings are thus relieved of practically all load except for the weight of the parts. The action of the explosion in driving apart the pistons $A$ and $B$, drawn together by means of the oblique rods, the pistons $C$ and $D$, compressing the charge between them so that the negative work of compression is performed not through the cranks and connecting rods but directly through the oblique rods and only the net useful work is transmitted to the crank shaft. Further, as each stroke includes compression and explosion, the reciprocating parts are cushioned at each end of every stroke, the combined effect of ignition and cushioning having for their purpose the keeping of the oblique rods in constant tension as well as making the crank effort more uniform.

The balance of the engine is practically perfect. The center of gravity of a pair of pistons, Figs. $B$, $A$ and $D$ for instance, is at the point $P$ and moves up and down on the line $PQ$, while the center of gravity of the other pair is at the point $Q$ and moves down and up on the same line. The author claims that this is probably the only engine in which the centers of gravity of the balancing masses have the same identical locus. If the forces working in this mechanism be divided into two rough classes, which, for the purpose of brief description, the author calls "useful" and "useless," the only ones falling into the latter class are the minor reactions from the slippers at the end of the oblique rods, constant in direction and less, both in number and amount, than the similar reactions of any other reciprocating engine in common use, whether gas or steam.

In regard to weight, the new construction, by combining eight two-stroke pistons with four cranks, produces a given power upon $^1/_2$ to $^1/_3$ the weight required with other constructions. From a heat point of view, the double type of cylinder has material advantages, and further, such cylinders require but one crank each. In form, the cylinder is a plain tube, supported at either end but free to expand axially and with its fellows is surrounded by a common tank forming the water jacket. In such a cylinder, temperature stresses cannot occur and moreover, in the absence of corners or pockets, the actual mean temperature of the inner surface of the cylinder is very low.

To test the system, an engine of 500 h.p. was built and installed in the engine room of the Newcastle Electric Supply Company. It is of the stationary type and weighs, without the flywheel, under 20 tons. As it develops continuously some 550 b.h.p., its weight is less than one-half of that of gas engines of equal power. A very interesting feature is the ease of repairs. An upper piston can be withdrawn in ten minutes after stopping the engine and the lower piston lifted out through the cylinder in three minutes more. The whole of the eight pistons can be withdrawn in an hour with the use of a hand crane only. In spite of the fact that the air and gas supply auxiliaries are somewhat of a make-shift in character, the over-all efficiency during a 30 hour test was found by Professor Hopkinson to be just under 30 per cent, with the indicated efficiency 37.6 per cent, and the mechanical efficiency about 90 per cent. The chief interest of the system is claimed to be in the promise it holds out of much larger powers with fewer and lower stresses.

In the discussion which followed, Richard W. Alan took up the question of the use of oblique rods in the Fullagar engine. At first, he was somewhat uncertain about the vibration of the rods and in order to safeguard against any accident which might arise out of these oblique rods, a special form has been constructed in which the rods were placed both with the top and bottom pistons; a hydraulic pressure of 50 tons applied to the rods gave only an extremely small deflection. To insure freedom from vibration, vertical guides have been placed on the oblique rods, which have a damping effect and in actual practice they experience no trouble whatever.

## UNIVERSITY OF ILLINOIS

*Bulletin, vol. 12, no. 10, November 9, 1914, Urbana, Ill.*

THE ANALYSIS OF COAL WITH PHENOL AS A SOLVENT, S. W. Parr and H. F. Hadley.

Report of work done at the Engineering Experiment Station of the University of Illinois, treating of a method of coal analysis in which the cellulose and rosinic substances are separated by means of a solvent, the main solvent used in this investigation was phenol. While the paper does not contain a regular bibliography in the subject, it gives numerous references to previous investigations and an interesting historical sketch of coal analysis.

The purpose of this method of analysis is to separate in unaltered form the fundamental substances of which coal is composed and to study their characteristic properties in detail. By this means, it has become possible to study separately the insoluble residue and the extracted matter; to de-

termine which has the greater avidity for oxygen, and to which division belong the coking constituents and special products of decomposition, such as gas, illuminants and tar.

This is therefore of particular importance to the gas and coal tar products industries.

It was found that phenol at 212 deg. fahr. will dissolve constituents of bituminous coals in their natural states and that the two sub-divisions designated respectively as insoluble residue and extracted matter together make substantially 100 per cent of the amount of the original substance. Studies upon these two type substances indicate that the extract is the vital constituent concerned in the coking of coal, that it has a sufficiently definite melting point, and a decomposition temperature which is above that of the melting point.

Each sub-division is capable of absorbing oxygen, but the insoluble portion has the greater avidity for it. The effect of absorbing oxygen upon the extract is to modify its coking properties by lowering or greatly reducing its power to form a firm and coherent mass. The oxygen taken up in either case is found to be chemically combined and the oxygen taken up by fresh coal is similarly held.

Previous work has shown that oxidation was playing an important role in producing changes in the residue and extract. It was desired, therefore, to establish whether the loss of coking properties was due to oxidation or simple absorption of oxygen as well as to see what effect the heating at 105 deg. cent. (221 deg. fahr.) would have on the percentage of volatile matter. Coal was heated therefore in air at the above temperature for different lengths of time and volatile matter determinations were made at successive stages of oxidation, and it was found that the volatile matter decreased with progressive heating and that the decrease in volatile matter was more rapid in the case of the coal which had the higher percentage in the beginning. It was found also that residue and extract possess an avidity for oxygen, the residue showing the greater avidity. The ultimate analysis of the coal residue and extract show that the per centages in both of carbon, hydrogen, nitrogen and oxygen are substantially the same. (41 pp., 6 figs. *cp.*)

# SOCIETY AND LIBRARY AFFAIRS

## MEETINGS

### BOSTON, JANUARY 6

The meeting of the Boston Section on January 6 was devoted to the subject of Aviation. Albert Adams Merrill discussed the problem of fore and aft stability. He said that as long ago as 1871, the French aviator, M. Penaud, had shown the value of the longitudinal dihedral, composed of two surfaces, the front one being the main supporting surface and the rear one being a non-lifting tail. The dihedral was obtained by making the angle of incidence of the front surface greater than the angle of incidence of the tail, which in the Penaud models had a negative angle.

The trouble with all cambered surfaces is that the center of pressure moves in the wrong direction with a change in the angle of incidence within the limits of flying angles, but by using two surfaces with a longitudinal dihedral between them, the movement of the center of pressure of the system can be altered so as to get any desired movement. Practically all machines get their dihedral between the supporting surfaces and a non-lifting tail. Mr. Merrill claims this is not the best way for two reasons. First, because the tail is not a weight carrier and hence wastes power, and second, because the horizontal gap between the tail and the main surface produces a time lag in the introduction of the righting couple which is bound to set up oscillations about the lateral axis. To overcome this, Mr. Merrill designed a biplane in which the top surface is ahead of the lower surface and the chords are not parallel, the angle of the front being greater than that of the rear. Such a machine is called a converging staggered biplane. With this design the dihedral exists between the two supporting surfaces and no tail is necessary. Such a machine was built and flown during the last summer, first as a land machine and then over water. With this design, it is possible to get any desired movement of the center of pressure of the system. Mr. Merrill illustrated his talk with blackboard designs and small paper flying models.

Greely S. Curtis, of the Burgess Company of Marblehead, presented a number of interesting slides showing aeroplanes in flight and also showed a number of charts. He mentioned that during 1914, there had been little advance in speed or duration of flight, the speed record standing at approximately 123 miles per hour. In regard to inherent stability, many experiments had been made with the Dunne machine and with the Dunne-Burgess type at Marblehead, which practically eliminate stalling and diving and require but little manipulation of hand control levers governing the stability. Mr. Curtis showed cuts of the Sperry gyroscope stabilizer.

Prof. Joseph C. Riley, of the Massachusetts Institute of Technology, showed many lantern slides of gasoline engines including four, six and eight cylinder models. He stated that a four cylinder model won the foreign competition prize in 1912 for a seven hour test. Later in the British competition, no engine with less than six cylinders was allowed to enter. He called particular attention to the Bentz engine which has proved so economical. He pointed out the trouble in balancing a four cylinder engine to do away with vibration and called attention to the advantages of six and eight cylinder designs. He also showed illustrations of the rotary types and mentioning particularly the Gnome.

The attendance at this meeting was about 125.

### BUFFALO, JANUARY 7

A meeting of the Buffalo Engineering Society was held on January 7. The meeting was addressed by Prof. J. A. Moyer of the Pennsylvania State College who spoke on Recent Development in Steam Turbine Engineering. After giving somewhat of a history of the early development of the steam engine, he gave a full and complete explanation of the new mercury turbine which is now being developed at Schenectady. There was some spirited discussion of

Prof. Moyer's paper. The attendance at the meeting was about 160.

## CHICAGO, JANUARY 8

A meeting of the Chicago Section to which the members of the Western Railway Club were invited was held on January 8. The speakers of the evening were R. M. Ostermann and Clement F. Street who covered the subjects of superheaters and mechanical stokers respectively and Willard A. Smith, president of the Railway Review, who spoke of Railway Economics.

In discussing superheaters, Mr. Ostermann explained concisely, with the aid of stereopticon views, the construction of the superheater and cited by means of diagrams, the results of tests showing the nature and extent of the economies derived from the use of this apparatus.

Robert Quayle discussed the superheater experience of the Chicago and Northwestern Railway which has in use, 425 superheater locomotives. From the shop and round house point of view, importance was laid on the possibility of suppressing steam leaks and keeping the flues open for the ready passage of the gases around the superheater units. An experimental equipment containing a pyrometer has been installed in some cases indicating to the men in the cabs, the temperature of the steam at all times passing through the cylinders, and in this way suggesting such defects in manipulation as holes through the fire, excessive thickness of fuel bed, steam leaks in the front end or in the operative damper. In regard to lubrication, difficulties have been overcome to a large extent by getting the enginemen into the habit of running on cracked throttle whenever the engine is not running under power, and this made possible the general return to the usual grades of valve oil instead of the more expensive kinds that at first were thought necessary. While the fuel savings vary with the intelligence and alertness of the engine crews, on the average they are believed to amount to twenty per cent of the amount required by non-superheater engines. The saving in water consumption was such that switchers were found to be able to work nearly fifty per cent longer on a given amount of water than they did before superheaters were applied.

The boiler pressures now prevailing on superheater locomotives of the Chicago and Northwestern Railway are thirty pounds less than on the non-superheater motive power and this together with the adopted practice of regularly assigning crews to engines may have been the cause of the fact that the direct maintenance expense was found not to be appreciably greater than similar expense on the non-superheater class. Superheater equipment has also proved very popular with the men.

In regard to mechanical stokers, Mr. Street spoke of the magnitude of the railway industry and the influence exercised on it by the efficiency movement in the use of the coal in the firebox of the locomotive.

H. T. Bentley of the Chicago and Northwestern Railway stated that his road has not yet felt a real necessity for stoker equipment partly because its locomotives are relatively small and also on account of the fact that the labor of the firemen has been greatly reduced through the use of coal pushers, for the purpose of delivering the coal to the forward end of the tender and within easy reach of the firing deck.

This was followed by a series of answers given by Mr. Street to questions raised by the audience. One of the statements made in this way was that by the use of the stoker in one instance, slack at 60 to 75 cents per ton has been successfully fired in competition with run of mine, hand fired, costing from $1.20 to $1.50 per ton, and at the same time with improvements to the ability to handle traffic.

In the discussion of the subject of Railway Economics, Willard A. Smith, of the Railway Review, Chicago, cited the evident trend of affairs in regard to maintenance of equipment costs resulting from the extended use of high capacity cars and locomotives. Numerous figures were cited to indicate this condition, not the least impressive of these was that had a reduction of ten per cent been made in the maintenance of equipment costs on the roads of this country for the last fiscal year, it would have made possible the doubling of the dividends paid and also that were the seemingly plausible saving of 20 per cent to be made in the maintenance of equipment costs on the basis of last year's returns, the dividends could be quadrupled. At the rate maintenance of equipment expense has been increasing during the past ten years, it is to be anticipated that in five years, this item will represent as large an expenditure as does operating expense. On some roads, maintenance of equipment costs already exceed those of operation. On other roads this expense is greater than the entire passenger revenue. On others, locomotive maintenance alone costs 25 per cent more than those roads expend for fuel. Since 1900 the average tractive power of locomotives has increased 36 per cent while the cost or maintenance to those locomotives has increased 93 per cent. The average freight car capacity in the same period has increased 34 per cent, the average load 28 per cent, while the freight car maintenance costs have advanced 67 per cent. Freight car maintenance costs have so far advanced that they now amount to approximately two and one-third times fuel and locomotive maintenance costs combined.

As a possible means of solution to the problem which the railroads are confronting in this connection, it was suggested by Mr. Smith that there be established a national bureau of railway engineering whose functions would be to investigate conditions as to nature and capacity of equipment, roadbed, terminal facilities, etc., and render to the roads seeking its services such recommendations in each case as the country's best engineering, and administrative talent and experience could afford. In Mr. Smith's opinion, a bureau of this nature might properly be established in one of three ways, enumerated herewith in the order of their preference: First, a governmental bureau, for which ample precedence is afforded in the Department of Agriculture and in the Bureau of Mines; second, by private endowment, an action which not a few individuals or establishments having achieved their success through the patronage of the roads of this country, could well afford to take with lasting benefit to the roads and distinction for themselves; and third, through a commission to be created by the roads on their own responsibility, to be supported by them jointly and to render an impartial service to all roads alike. This latter plan, it is believed, would constitute an important initial step in any event, since such an organization should have no difficulty in attracting attention to the very valuable results to be derived from the work in which it would become engaged and thereupon should have no great difficulty in enlisting governmental or other outside support.

At the conclusion of Mr. Smith's remarks, Dr. W. F. M. Goss, whose presence had been anticipated during the discussion of the technical subjects earlier in the evening, was introduced, but owing to the lateness of the hour, he made only a few remarks.

This account is abstracted from the report given in the Railway Review, January 16, 1915.

### ST. LOUIS, JANUARY 11

The Annual Meeting and Dinner of the St. Louis Section were held on the evening of January 16 at which Chairman Bausch acted as toastmaster. The speakers were Edward Flad, Consulting Engineer and Member of the Board of Freeholders; E. R. Kinsey, President of the Board of Public Service; Joseph A. Hook, Director of Public Utilities, Board of Public Service and E. R. Fish, Secretary of the Heine Safety Boiler Company.

Mr. Flad told of the framing of the New Charter for the City of St. Louis and particularly of the things in it of interest to engineers, dwelling especially on the board of efficiency, the introduction of the merit system in the hiring of city employees, and the concentration of power and responsibility in a board of public service consisting of five members, the president, and two members who must be engineers of at least ten years' experience.

Mr. Kinsey told of the scope of the duties of the Board of Public Service and how splendidly the provisions of the New Charter in regard to this board were working out. Under the New Charter, there has been an entire reorganization and separation of the departments each being placed under the supervision of specialists.

Mr. Hook spoke of some of the problems of his department, particularly that of the Free Bridge and the River Terminals, and asked the coöperation of the members. Suggestions were offered by Messrs. Boughton, Hibbard, Hunter, Kinsey, Satz, Flad, Nordmeyer and Wadleigh.

Messrs. Wadleigh, Seubert and Hunter gave brief reports of the St. Paul-Minneapolis meeting and Mr. Fish gave a report of the Annual Meeting.

### NEW YORK, JANUARY 15

The New York meeting for January was held on the 15th of the month instead of the usual second Tuesday. A lecture was given by T. Kennard Thomson, D.Sc., consulting engineer, on A Really Greater New York. The lecture dealt in the main with the mechanical problems connected with the building of foundations for tall buildings and bridges particularly where caissons are required. Dr. Thomson showed many views of the foundation work in New York City, both past and present, of some of the best known buildings and explained in detail the many problems connected with the use of compressed air in caissons especially where as is the case in Manhattan, foundations must be carried to a great depth. The subject matter of the lecture naturally led to a discussion in conclusion of the possibility of a greater New York acquired through the construction of new land extending into the harbor and the East River with new transportation channels. This means that a greater increase of shore front could be secured to accommodate greater ocean traffic together with the facilities for handling freight including warehouses and other buildings.

### PHILADELPHIA, JANUARY 14

A joint meeting of the Philadelphia Section with the Metallurgical Section of the Franklin Institute was held on January 14 with Prof. H. E. Ehlers and Prof. A. E. Outerbridge jointly presiding. Robert R. Abbott, Metallurgical Engineer for the Peerless Motor Car Company, presented a paper on Modern Steels and Their Heat Treatment. After considering the mixtures and compounds of iron and carbon present in steels, the proportions of these contained in steels of different carbon contents and their influence upon the strength of the material as indicated by percentage reduction in area in tension, the speaker described the effect upon the iron-carbon constituents produced by alloying with iron other elements such as nickel, chromium, manganese, etc. He then compared with this latter, the effects produced by heat treatment, showing that such effects were practically the same as those produced by alloying. He concluded with an outline of the commercial applications of heat-treated steel. The speaker illustrated his remarks by means of lantern slides of photo-micrographs and charts.

The paper was discussed by Prof. A. E. Outerbridge, Prof. Edgar Marburg, G. R. Henderson, H. V. Wille, Dr. Carl Hering, H. A. F. Campbell, E. W. Finkbiner, J. T. Fennell, and others.

### CINCINNATI, JANUARY 21

A joint meeting with the Engineers' Club of Cincinnati was held on January 21. R. W. Rew of the Department of Public Service of Cincinnati spoke on the Engineering Features of the Proposed Rapid Transit System. About 100 members and guests were present.

## NECROLOGY

#### HERBERT NICHOLAS FENNER

Herbert Nicholas Fenner was born in Providence, R. I. on March 13, 1843. He obtained his early education in that city and after a few years experience in business, he succeeded his father in the New England Butt Company. He served as treasurer of that company for many years and at the time of his death was president. He was also a Director in the Industrial Trust Company and the Joslin Manufacturing Company.

Mr. Fenner took a great interest in public affairs, but never held political office. He was prominent in club life and was a director of the Puritan Life Insurance Company.

He died in Providence, R. I., on January 5.

#### HERBERT SELBY HAYWOOD

Herbert Selby Haywood was born at Brooklyn, N. Y., on September 19, 1845. His parents moved to Elizabeth, N. J. in 1852 and he was educated at Rev. David H. Pierson's school in that city. In 1862, he entered the Novelty Iron Works in New York City and served a four years apprenticeship in marine construction work and engineering. In July 1866, he entered the service of the Pacific Mail Steamship Company and made a voyage on the Steamship "Montana" through the Strait of Magellan to San Francisco. On several other long trips during the years 1866 to 1872, he filled positions as 2nd and 1st assistant and acting chief engineer. For about four years, he was detailed to service on branch lines on a steamer plying between ports in Japan, China and the Siberian Coast.

In April, 1873, he entered the service of the Pennsylvania Railroad Company as machinist in the Altoona shops. In 1874 he was detailed for special duty on the United Railroads of N. J. division as Assistant Road Foreman of Engines. He was appointed Assistant Superintendent of Motive Power in 1875 to which the marine department was added in 1881. In 1882, he was appointed Superintendent of Motive Power of this same division and also of the United Railroads of N. J. Division in 1883 and of the Camden and Atlantic R. R. including the ferries and floating equipment on the Delaware River in 1884. He had supervision of the motive power and marine equipment of the New York, Philadelphia and Norfolk Railroad from January 1, 1890 until his death.

During the 80's, he took out several patents, including an interior check valve on a locomotive boiler, one for a car journal box and another, a cut off valve for a beam engine. This cut off valve was adopted by practically all of the ferries in New York harbor.

Mr. Haywood was one of the oldest members of the Society having become a member in 1880. He was also a member of the Society of Naval Architects and Marine Engineers, the Engineers' Club of New York, the Engineers' Club of Philadelphia and the New York Railroad Club. He died December 14, 1914.

### CHARLES A. MOORE

Charles A. Moore, President of Manning, Maxwell and Moore, Inc., New York, was born at Sparta, N. Y. nearly 70 years ago. When he was 12 years old, he went to Lynn, Mass. to live with an uncle and receive his education. In 1862, he enlisted in the United States Navy and served until the end of the Civil War.

Fifteen years of his early business life were spent in and about Boston. During this time, he was connected with the Ashcroft Manufacturing Company and the Consolidated Safety Valve Company in the manufacture of steam specialities.

Mr. Moore later came to New York to be with H. S. Manning & Co. In 1881, the firm name was changed to Manning, Maxwell and Moore. At Mr. Maxwell's death in 1895, the business was left in the hands of Messrs. Manning and Moore. Mr. Manning retired in 1905.

In his busy years, Mr. Moore was very active in Republican politics. He was President of the American Protective Tariff League, and one of the founders and for ten years president of the Montauk Club in Brooklyn, N. Y., a member of the New York Chamber of Commerce, and the National Association of Manufacturers and several other societies and clubs. Mr. Moore died on December 8, 1914.

### FRANK RUSSELL PACKHAM

Frank Russell Packham was born at Hadley, Michigan on May 11, 1855. He received his early education in Canada and his first business training with his father who was a miller. He also served an apprenticeship in a sewing machine factory and learned the machine and pattern making trades.

When he was 18 years old, his parents moved to Springfield, Ohio, where Mr. Packham was employed as a machinist for the Wardell-Mitchell Company which is now a part of the International Harvester Company.

In 1878, he became superintendent and experimental man for the Baker Drill Company in Mechanicsburg, Ohio, and manager and designer of turner's tools for the Packham Crimper Co. until 1886.

In 1887, he returned to Springfield and identified himself with the Superior Drill Company devoting his time to designing and pattern making.

Upon the formation of the American Seeding Machine Company, Mr. Packham was made a director of the company and manager of the experimental department. This position, he held until the time of his death.

As an inventor, Mr. Packham contributed as many as 150 improvements on various agricultural implements, most of which are now manufactured by the American Seeding Machine Company. Probably his most important work was the invention and development of the "single disc" drill.

In 1900, Mr. Packham was appointed by Secretary Wilson as a representative of the United States Government to tour the world in the interests of the Foreign and Domestic Bureau of Commerce. In 1909, he was appointed mechanical guide to the Honorable Commercial Commission of Japan in its visit to this country.

Mr. Packham died at Springfield, Ohio, on January 1.

### WILLIAM R. ECKART

William R. Eckart was born in Chillicothe, Ohio, June 17, 1841. His relatives were pioneers in the settlement of that part of the State, but in 1842 his family moved to Cleveland, where his father had large shipping interests on the Great Lakes. His early education began in private schools, but from the time he was twelve years old his school days were divided between the public schools of Chillicothe and Cleveland. Later, he took a special course in mathematics at the St. Clair Street Academy, Cleveland, with the view of becoming a civil engineer.

In the early fifties his father removed to Zanesville to engage in the operation of a flour mill, operated by water power, and after the installation of some improved water wheels, Mr. Eckart received the opportunity to serve an apprenticeship in the works of Griffith, Ebert and Wedge, which in those days, had a high reputation for general mill and steamboat work; this was a welcome opportunity as the fascination of steamboat work had taken hold of his ambition while traveling on the Ohio and Mississippi rivers. In his apprenticeship he was fortunate in having the friendship and guidance of Mr. Wedge, who found the time to show him how to improve upon his work after he had thought it "good enough."

Mr. Eckart's river experience aroused a desire for naval life, and in June, 1861, he took an examination before the Board of Engineers. On July 30, when he was twenty years of age, he was appointed Third Assistant Engineer in the navy and was ordered at once to join the fleet of naval vessels on the Pacific coast. On July 10, 1864, Mr. Eckart resigned from the navy on account of ill health and took up his residence in San Francisco, where he began work in the drawing room of H. J. Booth and Company. While with this company, he made the designs and drawings for the first California built locomotive. He remained with this company until February, 1869, when he received an appointment as draftsman in the Steam Engineering Department at Mare Island Navy Yard. He was afterwards made foreman machinist and later was promoted to superintendent of steam machinery through B. F. Isherwood's recommendation.

In 1871 Mr. Eckart left the Navy Yard to enter into partnership with Prescott, Scheidel and Company, at the Marysville Foundry. The firm name was later changed to Booth and Eckart. It was while there that Mr. Eckart contracted for, designed and built the steamer Meteor for the Carson Lumber Company, with a guaranteed speed of 21 miles per hour; this steamer was used on Lake Tahoe and was probably the fastest boat of her size known at that date.

In 1876 Mr. Eckart was recalled by the Prescott, Scott and Company, who were the successors to H. J. Booth and Company, to superintend the construction and assist in designing and erecting some pumping machinery for the Comstock Lode. About this time he moved to Virginia City to become consulting engineer to the "Bonanza Firm" that owned or controlled nearly all of the "North End" Mines. During this time he was manager of the Fulton Foundry, Virginia City. In 1878 he was appointed U. S. Deputy Mineral Surveyor for the State of Nevada. While still a resident at Virgina City he designed and built, in connection with W. I. Sakeld, a noted millwright at that time, the Bulwer Standard Mill, at Bodie, which was one of the largest pan mills for working ore that had been built at that time.

During the early part of 1880, Mr. Eckart was appointed a member of the U. S. Geological Survey under Clarence King and was given charge of investigating and reporting upon the mechanical appliances of the Comstock Lode. On this work, which was really a labor of love, he spent nearly two years collecting data, testing pumps, engines and hoists, and making drawings for the Government of all the machinery on the Comstock. The finest instruments procurable in the United States and Europe were used in the various investigations of efficiency.

In 1881, Mr. Eckart removed to San Francisco and opened offices there as a consulting and constructing engineer, and during the following eight or ten years some of the largest and most important mining plants were designed and constructed under his supervision. The pumping engine for the Ontario Mine, with perhaps the largest Cornish pumps for deep mining ever built in the United States, were constructed from his designs during this period. In 1881, he began for Haggin and Tevis, plans for all of the Anaconda Works, hoists and reduction works, and during the next seven years, all their mining work and mills were designed by him.

In 1883, The Union Iron Works, formerly Prescott, Scott and Company, was changed to an incorporated company and Mr. Eckart was retained as consulting engineer in matters pertaining to the propelling power of the Government vessels built by that company. He was present at and assisted in conducting nearly all the preliminary and government trials of these vessels.

In 1899, he was appointed consulting engineer to the Standard Electric Company and afterward became the resident construction engineer for all their hydraulic works, including storage, reservoir, ditches, dams, flumes, pipe lines and power house installations. This was the first or among the first of the long distance, high-potential-transmission, hydraulic plants projected.

Mr. Eckart was a member of the American Society of Civil Engineers, The Institution of Mechanical Engineers, The Society of Naval Architects and Marine Engineers and an Associate Member of the Institute of Naval Architects. He was Vice-President of this Society from 1883 to 1886.

Mr. Eckart died at the home of his son, in Palo Alta, Cal., on December 8, 1914, after a very successful engineering career covering a period of fifty years' practice on the Pacific coast, which, as he once said, was due "to a studious life surrounded by an extensive collected engineering library of American and foreign books and the appreciative assistance of associated engineers, together with the encouragement and loyalty of employers."

## PERSONALS

Louis H. Mesker has accepted a position with the sales department of the Kearney & Trecker Company, Milwaukee, Wis. He was until recently connected with the Anderson Forge and Machine Company, Detroit, Mich.

Henrik Greger, recently associated with the Epping Carpenter Pump Company, Pittsburgh, Pa., as assistant chief engineer, has become affiliated with The Prescott Company, Menominee, Mich., as mechanical engineer.

Alfred W. Charles has accepted the position of chief draftsman with the Canadian Copper Company, Copper Cliff, Ont., Canada. He was formerly connected with the Anaconda Copper Mining Company, Butte, Mont., in the same capacity.

Russell B. Bedford until recently President of the Railway Material Export Corporation, New York, has assumed the position of export manager and manager of the Eastern branch of the Clarage Foundry and Manufacturing Company, Kalamazoo, Mich., with headquarters in New York. He is also engaged in personal consulting engineering work.

Arthur G. McKee has lately formed a corporation with his two business associates, Robert E. Baker and Donald F. Herr under the name of Arthur G. McKee and Company.

Henry Souther, Chairman of the Standards Committee of the Society of Automobile Engineers, has been made a life member of that Society in recognition of his distinguished achievement in the orderly development of the art of automobile engineering. At the Annual Meeting of that Society, Mr. Souther was presented by his associates with a silver piece suitably engraved, as a token of the admiration and affection in which he is held.

H. C. Spaulding has severed his connection with the Society for Electrical Development and is now connected with the Frank Presbrey Company organizing their electrical service department.

Edward M. Hagar was appointed Honorary Vice President to represent the Society at the American Road Builders' Association in Chicago at its Eleventh Annual Convention, December 14-18, 1914. This convention was held in conjunction with the Sixth Good Roads Show. The commercial exhibits included samples used in road construction and maintenance, such as stone, gravel, asphalt, tars and brick, together with exhibits illustrating the various exhibits employed in the testing of road material; sections of patented pavements and pavements built with patented materials; construction equipment varying from tools to heavy machines; models of contractor's equipment, engineering and testing instruments.

In the arena of the amphitheatre in which the show was held an oval boulevard was laid out surrounding a park which was set with trees, and contained a gravel walk and a fountain. The boulevard proper was constructed of various types of paving materials, such as asphalt, macadam, brick, wood blocks, concrete, tar, macadam, and asphaltic concrete. The exhibits bordering the parkway were those of the Bureau of Streets of the cities of Chicago, New York, Philadelphia and Boston, and of the State Highway Commissions of Illinois, Michigan, Iowa, Arizona, Washington, Kansas, Kentucky, New York, Virginia, Rhode Island and

Maine and of the North Carolina Geological and Economic Survey. In addition, the United States Government was represented by a very interesting exhibit from the office of Public Roads of the Department of Agriculture, and Canada, by an exhibit from the Highway Commission of Ontario.

## STUDENT BRANCHES

### CARNEGIE INSTITUTE OF TECHNOLOGY

At a meeting of the Carnegie Institute of Technology Student Branch on January 13, E. H. Bickeley, C.I.T. '09 read a paper on some of the things he had learned and done since he left Carnegie Institute, and made the following suggestions to the students: know your materials; learn from the practical man; everything we do, think or say has a cost; what you cannot produce quickly is not your own; what you can produce quickly is what you are valued at.

Mr. Bickeley then told of some of his work at the H. J. Heinz plant at Pittsburgh. He cited a number of instances to show how wastes had been eliminated and explained his system of card indexes and curves which he used in keeping track of the various operations going on in the plant. For instance, in a department where water or compressed air is being used, meters are put in the line. A report is received from the foreman of the department and this is plotted on the curve. A rise in the curve immediately denotes that there is something wrong.

The speaker then described his invention, the motorgraph which is an electrical sign on which the letter forming words appear at the right side of the sign and move across the face, disappearing on the left side. The lettering and motion is controlled by a moving perforated strip of paper and because of this simple control, changes in the lettering can be made almost instantly, and a continuous stream of different reading matter can be flashed across the sign.

### COLORADO AGRICULTURAL COLLEGE

At a meeting of the Colorado Agricultural College Student Branch on November 19, the following officers were elected; A. T. Johnson, chairman; W. K. Morrison, vice-chairman; and T. H. Sackett, secretary-treasurer. A programme committee was appointed consisting of the chairman, vice-chairman and the secretary.

At a meeting on November 23, the progress of Oxy-Acetylene Welding was reviewed by E. S. Murray and Standardizing Machinery was discussed by W. K. Morrison.

On December 7, Recent Developments in the Diesel Engine, by H. R. Setz was discussed.

At a meeting held on January 4, Prof. Albert Cammack gave an extemporaneous talk on Tool Steels. He outlined briefly the history of the development of tool steel, speaking particularly upon the tests, use and manufacture of modern high speed steels. He discussed hardening and tempering steels and the economy resulting in the employment of the high speed steels.

### KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch on January 14, Prof. S. L. Simmering of the mechanical engineering department gave a paper on Manufacturing Wire Nails. From the ore as taken from the mine, Mr. Simmering told of its progress through the plant until it comes out a finished product. When the ore is first received, it is run through the crusher and a sample for chemical analysis is taken from each lot and from this, the amount of impurities is determined. In making up a charge for the blast furnace, the ores are mixed in proportions so that the resulting iron will be within the allowable limit of impurities. The iron is taken from the blast furnace to the Bessemer converters and made into steel, which steel is cast into ingots and then rolled to a square about four by four in. and cut into twenty-four inch lengths. These blocks are then heated and rolled to a three-eighths in. rod. This rod from the rolling mill is coiled in bundles the same as wire, heated and annealed in lime. It is then cold drawn to the size required for the nail. One machine makes the complete nail.

### KANSAS UNIVERSITY

At the regular meeting of the Kansas University Student Branch, on January 7, S. E. Campbell discussed an article on Cost Accounting by William Kent which appeared in Industrial Engineering. He spoke principally upon its economic value in large plants rather than upon methods of keeping cost accounts.

Dean P. F. Walker, Honorary Chairman of the branch, spoke briefly on the Annual Meeting at New York. He gave a general outline of the whole meeting, explaining how it was conducted and touched slightly upon some of the papers given.

At a meeting on January 14, Dean Walker continued his talk and spoke of the purpose and value of engineering societies of all branches to the engineering profession. Although he spoke more specifically of the Am. Soc. M. E., he gave briefly the histories of many other important engineering societies such as the American Society of Civil Engineers and the American Institute of Electrical Engineers.

### LEHIGH UNIVERSITY

Prof. Thomas E. Butterfield and a party of Seniors from Lehigh University visited New York during the week January 4-9 on their annual tour of inspection of large engineering plants. A visit was made to the Engineering Societies Building, where the students were shown the Library with its wealth of engineering and scientific literature, the headquarters of the Mining, Electrical and Mechanical Engineering societies and the Museum of Safety, where there is a permanent exhibit of all types of safety appliances.

All students who intend to live in New York upon graduation are invited to make the Society their headquarters and avail themselves of the Library and other privileges.

### STEVENS INSTITUTE OF TECHNOLOGY

The Student Branch at Stevens Institute of Technology held its second lecture on December 15. J. I. Lyle, General Manager of the Carrier Air Conditioning Company gave a very interesting talk on Air Conditioning, giving examples of many of the applications of drying and humidifying air in the industries. The talk was appreciated because it dealt with subjects with which all of the hearers were conversant and because it was treated clearly and concisely. Views of air conditioning apparatus as used in its applications, were used as illustrations.

Another lecture was held on January 5. The speakers were I. E. Moultrop, superintendent of construction for the Boston Edison Company and J. W. Parker, assistant superintendent of operation of the same compaany. Mr. Moultrop gave a brief outline of the history of the company, describing its original equipment contrasting it with that of the present plant. He also enumerated the various items to be considered in choosing a site for a power plant. Mr. Parker told how the responsibility for each part of the work was divided among the men, and how the welfare of the workmen was taken care of. He also described the company's method of handling their peak load. Both speakers illustrated their talks with lantern slides.

### UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch on January 15, B. S. Hughes of Steigner, Hughes and Alvez, Consulting engineers, gave a lecture on The Problems of a Consulting Engineer. As an illustration of the conditions which may confront the consulting engineer, Mr. Hughes assumed that he was to build a power plant with a certain capacity and that the expense item was no object. For a plant which would be operated under these conditions, under a scientific management, and with a skillful staff, it would be advisable to install a high grade system of units, and probably include all of the modern heat-saving appliances. If, however, the plant was not to be

operated under scientific management, it would be advisable to install units of lower initial cost.

Mr. Hughes cited several examples which illustrated the various conditions affecting the design and operation of power plants. He mentioned the equipment of steam power plants with condensing units, where live steam was used for drying purposes in the factory which was an obvious waste of funds for initial cost and operation. Another case in which an important item was overlooked was that of the large paper mills in the South which were splendidly designed from an engineering standpoint, but which were surrounded by such unattractive local conditions that good men could not be induced to stay.

At the close of the paper, Prof. A. L. Jenkins, of the University of Cincinnati, and others informally discussed the paper.

### UNIVERSITY OF COLORADO

At a meeting of the University of Colorado Student Branch on January 14, R. N. Robertson, mechanical engineer of the American Smelting and Refining Company, spoke on Boiler Setting and the Altitude Effect. Mr. Robertson discussed rather fully the matter of boiler settings for different coals used at various altitudes. He brought out the principle points in connection with combustion under these conditions, giving the qualities of various coals and their relation to the design of furnaces. The speaker said that the altitude is a very important factor in combustion. About 50 per cent increase must be made in the flues and combustion chamber and 75 per cent increase in the height of the stack to cause the proper draft for complete combustion with the rarified air at altitudes of two miles or more.

Mr. Robertson showed some new designs of settings and results from his own experience with soft coals in the company furnace, and some new points on combustion. The speaker believes that the under-feed is the best form of stoker for all purposes and all conditions and that there is no doubt that it is coming to be the prevailing form.

### UNIVERSITY OF MISSOURI

The University of Missouri Student Branch held a meeting on December 17, at which Stanley Goodman and P. R. A. Nolting read and discussed their paper on The Effect of Various Constituents of Coal upon the Fusing Point of its Ash.

At a meeting on January 10, F. N. Westcott read a descriptive paper on the St. Louis Water Works System, and F. P. Hutchinson read a paper on Smoke Prevention.

## EMPLOYMENT BULLETIN

**Note: In sending applications stamps should be enclosed for forwarding.**

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

### POSITIONS AVAILABLE

010 Mechanical engineer as assistant superintendent for cement mill, New York State. Applicant should have a technical education as well as practical experience, and must have demonstrated his ability to handle men efficiently. One who has had cement mill experience preferred, and competent and willing to make a study of the repair costs. Salary $150.00 per month. Apply through Society.

011 Man capable of superintending power and plant and assisting production superintendent in large cement manufactory. Salary rate $150.00 per month. Location New England.

013 Assistant superintendent for chemical manufacturing plant in Middle West employing 1500 men. Chemical education and experience in handling men and machinery required; applicant please state age, education, previous experience, salary received heretofore and salary desired.

014 Mechanical engineer with good designing ability and large experience in conveying machinery to take charge of drafting and engineering department of company manufacturing conveying machinery. Give experience, references, salary expected and full particulars which will be treated strictly confidentially. Location Middle West.

015. Chief draftsman, man experienced in the design and manufacture of sheet metal products such as office furniture, filing cases, and similar equipment, competent to systematize and direct the work of thirty to forty men. Give age, education, experience, references, and the salary expected. New York concern.

019 Laboratory instructor. Salary beginning at $1500 per year with excellent opportunity for promotion. Location Nevada.

020 Resident engineer on construction and extension of cement plant in Tennessee. Salary between $150 and $200 per month. Apply through Society.

021 Good designing draftsman, experienced in designing automatic paper forming machinery such as envelope or paper box machinery, and one who has had several years of machine shop training. Location New York.

022 District representative wanted in one of the large Middle West cities to handle steam turbine account. Applicant must have had experience in steam engineering practice and the application of turbines, turbo-pump sets, turbo-generator sets and turbo-blower sets, and the sales ability necessary to the successful handling of the account. Apply through the Society.

023 Foundry and machine shop located in Metropolitan district wishes services of technical man with about ten to twenty thousand dollars to invest. Apply through Society.

024 Young man for work in efficiency department of middle west concern, with shop experience and possibly some experience in efficiency work. Will require a man with initiative. Applicants state in detail experience and give the approximate salary that would be considered. Names of former employers should be included.

025 General foreman of large machine shop manufacturing large generators and other work of a kindred character. Apply through Society.

026 Wanted party with capital to assist in financing the development of important improvements in the design and application of hydro-pneumatic apparatus.

029 An engineer of established reputation on the Pacific Coast desires partner with capital to form a corporation to engage in general engineering and contracting business. One who has had previous experience or technical knowledge and ability to get business. New York interview desired.

030 Agency wanted for small patented electrical device of foreign invention. Apply by number.

031 First-class designer in concern in New York State making paper printing, and book machinery, etc.

032 Large manufacturing company with modern steel working equipment and complete organization, has capacity larger than at present required. Will be pleased to hear from parties desiring the manufacture of their products. Apply through Society.

033 High grade shipping clerk to take charge of the output of a firm employing 750 men at the present time working night and day. Would consider only man thoroughly experienced. Location Connecticut.

036 Man to take charge of a foundry, machine shop and blacksmith shop now in course of erection; not necessary that he be a craftsman, but rather a good handler of men and with a knowledge of cost accounts, etc. Establishment is for repair work for large iron mines. Apply by number.

### MEN AVAILABLE

B-1 Junior, graduate M.I.T., mechanical engineer, age 30, married, five and one half years experience in design and construction of power plants and illumination of textile mills, sales of electro power, and preparation of contracts, desires position in engineer's office as assistant to manager, superintendent of a cotton mill, master mechanic or purchasing agent.

B-2 Junior, technical graduate in mechanical and electrical engineering, ten years experience in design, construction, operation and maintenance of power house and substations, high voltage electric design, piping design and layouts, etc., and building designs, desires position as power engineer, assistant superintendent of large mill, or designing engineer for large engineering firm or contractor.

B-3 Mechanical engineer, five years experience in design and reproduction of agricultural and marine gas and oil engines, one year in charge of mechanical and of a new food product, desires responsible position in production or sales department.

B-4 Member, 12 years experience in designing, as superintendent of construction, as transit man, in transmission, purchasing, shipments and office details, as operating superintendent of 3000 barrel cement plant, connected with plants in the East, Middle West and Central South, desires to connect with responsible firm. Location immaterial.

B-5 Mechanical engineer, well qualified by technical education, experienced in research along lines of engineering physics, desires position involving industrial research or experimental engineering. Would also consider position as salesman on the road.

B-6 Member, graduate mechanical engineer, age 34, 11 years successful experience in designing, manufacturing, experimental and sales engineering; gas and oil engines of small and medium sizes, gas and electric hoists and draw bridge machinery, gas and oil tractors, railroad water service, coal and ore unloading dredge machinery. Well qualified for position as chief draftsman, experimental or production engineer or assistant superintendent. Practical and resourceful in economic methods of manufacture.

B-7 Member with well established office in New York desires to correspond with responsible concerns in regard to representation.

B-8 Associate member, graduate M.E., 1910, age 33, three years experience teaching and two of practical experience, has ability to superintend and increase efficiency of production. At present employed as assistant superintendent of small factory, desires position along similar lines, or will consider other opportunities in mechanical engineering; would also accept teaching position.

B-9 Member, technical graduate, 15 years experience supervising design and construction of power plants, office and factory buildings, mechanical equipment and fire protection systems, drawing specifications and contracts, desires position along similar lines, or with consulting engineer. At present employed by large industrial corporation in administrative engineering capacity.

B-10 Member, 25 years experience in mechanical, electrical and automobile work, thoroughly up-to-date in economical manufacture and time saving methods, desires position as manager, mechanical engineer or salesman.

B-11 Mechanical engineer, technical graduate, age 30, thorough knowledge of all types of pumps and pumping machinery, gasolene and oil engines, sugar house machinery, drawing room, erection room, and engineering department, desires responsible position, sugar plantation work in Mexico or sales engineer in Brazil.

B-12 Member, 30 years experience in hydraulic forging machinery and other heavy machines for the manipulation of metal, desires position as designing adviser or executive along these lines. Can be engaged for part time if desirable.

B-13 Member, age 34, technical graduate, 11 years experience in mill engineering and central station work consisting of designing, drawing up specifications, buying equipment, supervising installation, managing operation and maintenance, good executive and accustomed to handling high grade men, desires position as works engineer or with consulting engineer. At present employed.

B-14 Engineer with ten years experience in building up sales organizations, factory improvements in paper mills, tanneries, chemical works, metal working plants, machine tool building, clothing industries, etc., and having established large consulting practice in management engineering for a firm of industrial advisers, desires position with similar engineering or accounting firm.

B-15 Electrical and mechanical engineer, graduate University of Illinois, 1901, post graduate, 1910-1911, E.E. and M.S., 13 years practical experience in testing, design, construction, operation and management of steam, electric and hydro-electric plants, including generation, high-tension transmission, distribution of electric light and power for mines and cities in the United States and abroad, investigations and reports, is open for immediate engagement. Location immaterial.

B-16 Member, Stevens graduate, 25 years experience, well established record with prominent concerns, engaged in interchangeable manufacture, especially apt on tool design for large production with high degree of accuracy, successful executive in engineering and productive lines, desires position as manager, superintendent or mechanical engineer.

B-17 Graduate M.I.T. in mechanical engineering, two years experience in maintenance of power equipment, plant and designing new factory building with large manufacturing concern, two years inspecting reinforced concrete and steel structures with irrigation project, familiar with reinforced concrete design, desires position with construction firm, or power and plant department of manufacturing concern.

B-18 Cornell graduate, age 33, one and one-half years study of railroads in Germany, eight years railroad shop experience, desires position with engineering or manufacturing firm, or shop machine tool works. At present employed as practical instructor of apprentices.

B-19 Cornell graduate, age 28, married, seven years experience as machinist, toolmaker, master mechanic and chief engineer in charge of power and refrigeration plant, desires position in experimental work, testing, design or teaching mechanical engineering subjects.

B-20 Mechanical engineer, student member, 1914 graduate of large Eastern university, desires position with industrial or commercial concern.

B-21 Junior member, M.I.T. graduate, age 27, married, four and one half years experience, including drafting, power plant, textile machinery, office and executive work, desires permanent position with reliable concern offering chance for advancement.

B-22 Student member, graduate of University of Missouri, desires engineering position of any kind which offers chance for advancement.

B-23 M.I.T. graduate in mechanical engineering, nine years experience in motive power department of a large railway system, desires position with railway company in either M. P. or C. T. department. Location immaterial.

B-24 Associate-member, graduate M.I.T., associate A.I.E.E., age 26, experienced in teaching and as foreman, assistant superintendent and experimenter, desires position with manufacturer or experimenter.

B-25 Graduate engineer with ten years practical experience in power, heating and refrigerating work, including installation, design and estimating, would like to have the opportunity of doing some work while confined to his home. Has had special experience in physics, chemistry and calculus and would be willing to do editorial work in these and in engineering subjects.

B-26 Member, graduate of M.I.T., with broad experience, would like executive position, or position as assistant to chief executive in large concern. At present employed but desires change.

B-27 Mechanical and electrical engineer, graduate W.P.I., age 26, experienced in machine shop and steel mill work desires to make change. At present employed.

B-28 Superintendent or factory manager familiar with most modern practice in machine shops, foundries and manufacturing plants, competent to design tools and fixtures for increasing production and reducing costs.

B-29 Mechanical engineer, age 31, 14 years experience, desires position in engineering, sales or drafting department. Detail of education and experience furnished to those interested.

B-30 Mechanical engineer, technical graduate, age 38, 13 years experience in manufacturing lines, shop, operating, drafting, engineering, efficiency, sales including railroad, Corliss engines, gas engines and producers, saw mill, mining machinery, transmission and special machinery, complete steam and gas power plants.

B-31 Junior, mechanical engineer, Columbia graduate with varied experience desires to connect with an industrial concern, not necessarily in an engineering capacity at the start. Location immaterial.

B-32 Engineer, Stevens graduate, age 31, unmarried, capable manager, excellent designer, experienced writer of specifications, has just completed supervision of several large manufacturing plants, desires position as chief engineer for firm of industrial engineers and architects. Especially with South, location immaterial.

B-33 Member, long and valuable experience in responsible positions in design and construction, supervision of printers' machinery, thorough knowledge of field and requirements and construction of rotary web presses, folders, flat beds, offsets, electrotypes and stereotype machinery. Employed as chief draftsman.

B-34 Member, technical graduate, age 34, married, 16 years experience, including wide shop drafting room and outside experience, mainly in automobile and motor truck lines. Capable of handling advertising and publicity and engineering department at the same time as shop details and executive correspondence. Location preferred vicinity of New York.

B-35 Member, technical training, age 35, married, 14 years experience with large industrial concerns in many capacities up to superintendent is open for a position requiring the services of an engineer executive whose predominating ability is along mechanical lines and who is capable of assuming charge of the operation of the works of a large department. At present employed.

B-36 Junior member, technical training, 11 years experience, including foundry and machine shop practice, design, reorganization, construction, equipment of mill buildings and power plants, estimates, schedules of materials, building specifications and appraisals, fire service piping, sewage disposal and surveying, also as assistant on steam engine turbine and boiler tests, desires to locate permanently as mechanical engineer, assistant to engineer or works manager.

B-37 Member, sales engineer, established in New York, with a broad acquaintance in New England and Middle Atlantic States, desires to secure an additional account, preferring plant equipment or steam specialty. Salary or commission.

B-38 Member, technical graduate, 15 years shop and drafting room experience designing and superintending construction; thoroughly trained in machine shop, pattern shop and foundry work, with exceptional ability in tool designing and inventive work, desires position as instructor of machine design or with consulting engineer or manufacturer where there is opportunity for advancement. Location preferred, Eastern or Central States.

B-39 Student member, age 26, technical graduate M.E., experienced as machinist, mechanical draftsman, desires position as assistant to engineer, superintendent or manager of engineering concern. Location immaterial.

B-40 Contracting engineer, college graduate, age 40, eight years experience as contractor for steel works, furnaces and structures, desires connection with steel company or firm of contractors.

B-41 Junior member, age 28, graduate mechanical engineer, five years practical experience, last two and one half years engineer of tests of large automobile company, desires position as assistant superintendent or engineer.

B-42 Mechanical engineer thoroughly familiar with design and operation of power plants, railroad electrical engineering, shops, etc., desires position.

B-43 Graduate mechanical and electrical engineer, experienced in design and construction of machinery, building, manufacturing, systematizing, accounting, refrigeration, desires permanent position in New York.

B-44 Mechanical engineer and superintendent, 12 years experience, in present position four years. Qualified to accept position as assistant general manager, superintendent, or mechanical engineer. Now employed but would resign to accept advantageous offer.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

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## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

John A. Brashear, *President* Calvin W. Rice, *Secretary*

Finance Committee, R. M. Dixon

House Committee, S. D. Collett

Library Committee (to be appointed)

Committee on Meetings, J. H. Barr

Committee on Membership, W. H. Boehm

Publication Committee, C. I. Earll

Public Relations Committee, M. L. Cooke

Research Committee, R. C. Carpenter

Committee on Constitution and By-Laws, Jesse M. Smith

LOCAL MEETINGS

*Atlanta:* Earl F. Scott
*Boston:* H. N. Dawes
*Buffalo:* David Bell
*Chicago:* S. G. Neiler
*Cincinnati:* J. B. Stanwood
*Los Angeles:* Walter H. Adams
*Milwaukee:* L. E. Strothman
*Minnesota:* Wm. H. Kavanaugh
*New Haven:* H. B. Sargent
*New York:* Edward Van Winkle
*Philadelphia:* H. E. Ehlers
*San Francisco:* C. R. Weymouth
*St. Louis:* F. E. Bausch

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal

Rolla C. Carpenter

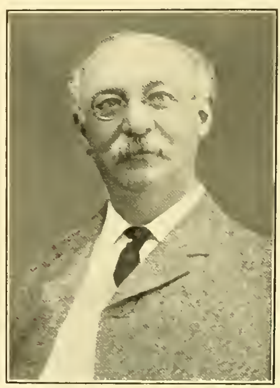
E. D. Meier (Deceased)

Chas L. Huston

John A. Stevens, *Chairman*

Edward F. Miller

Wm. H. Boehm



Richard Hammond

MEMBERS OF THE ORIGINAL BOILER CODE COMMITTEE, APPOINTED SEPTEMBER 15, 1911

THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 MARCH 1915 Number 3

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## COMING MEETINGS OF THE SOCIETY

*March* 9, *New York City.* Paper: The Application of Engineering Methods to the Problems of the Executive, the Director and Trustee, by Dr. Hollis Godfrey, president of Drexel Institute.

*April* 12, *Philadelphia, Pa.* Joint meeting with the American Institute of Electrical Engineers. Papers: Engine Driven vs. Turbine Driven Units in Small Capacities, by Albert C. Wood; and Washing and Cooling Air for Use with Electrical Apparatus, by an author to be announced.

*April* 21, *New Haven, Conn.* Spring meeting, with afternoon and evening sessions. Subject: The Development of Machine Tools.

*April* 23, *Boston, Mass.* Joint meeting under the auspices of the American Institute of Electrical Engineers.

*March* 11, *Buffalo, N. Y.* Subject: Interesting Features Involved in the Design of the Connors Creek Plant of the Edison Illuminating Co. of Detroit, by C. F. Hirschfeld of Detroit.

*March* 25, *Buffalo, N. Y.* First Member Speakers' Meeting. Papers: Present Status of Fuel Oil Engine in United States, by S. B. Daugherty of Snow Steam Pump Works; Conservation, by H. B. Alverson of Cataract Power and Conduit Co. (Niagara Falls Power Co.); and Power Equipment Used in Steel Plants, by E. E. Kiger of Lackawanna Steel Co.

*April* 2, *Chicago, Ill.* Subject: Power Plant Apparatus and General Equipment.

THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 March 1915 Number 3

# COMPLETION OF THE BOILER CODE

A SIGNAL event for the boiler industry and one that means much to the field of power production in general, was the completion of the report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for Care of Same in Service, and its presentation to the Council of the Society on February 13, 1915. Its approval by the Council—the governing body of the Society—and the authorization granted for immediate printing of the report as a Boiler Construction Code marks a new era in the manufacture of steam boilers, and it is hoped, will prove the inauguration of a movement of considerable importance for the protection of human life and property. The benefits that will accrue from an economical standpoint, when the rules for construction embodied in the new Code are generally put into effect, are far-reaching, and will affect alike the manufacturer and the user of boilers.

The work involved in the final revision of the Code was one of the most strenuous and trying committee undertakings ever carried out in the history of the Society. As stated in the February issue of The Journal, the work of revision began on December 15, 1914, and was carried on continuously without interruption until February 3, 1915, covering a period of nearly eight weeks of the most exacting and painstaking work. The Boiler Code Committee worked constantly in conference with the Advisory Committee which had been appointed in December and the sessions, which were both investigative and judicial in character, were marked by a peculiarly intense interest of the committee members and the most unusual display of energy. The daily sessions lasted usually throughout the day and until midnight and the attendance was usually a majority which is a matter worthy of note when it is considered that the committee members came from all parts of the country and some of whom were in constant attendance for the entire seven weeks. A notable feature of the final revision was the amount of research work involved, several series of tests having been carried out by members of the committee to check and establish the authenticity of the rules and formulae embodied in the Code.

The work of the Committee, as previously stated in The Journal, was confined to rules for construction of steam boilers only, all references to " other pressure vessels " and to laws and matters of legislation having been omitted. The result of the work of revision of the construction rules was the division into two parts, one for new installations and the other for existing installations, and following this was provided an appendix in which were placed the rules, examples, illustrations, references, and data that were in nature supplementary to the rules. As now laid out, the rules for existing installations (Part I) covers all details of construction of new steam boilers and the rules for allowable working pressures upon them, the details being referred to in the following order: Materials of construction, including the material specifications, maximum allowable working pressures, boiler joints, braced and stayed surfaces, combustion chambers, tubes, riveting and calking, manholes and handholes, safety valves, water and steam gages, and fittings and appliances. At the end of Part I is a section devoted to heating boilers, in which the above order of subjects is also adhered to. In Part II which is devoted to existing installations, the same order of subjects is followed, although less complete and exacting in details.

The text of the Code in its revised form was printed in the form of printer's galley proof and sent to each member of the Council of the Society, as well as to each member of the Boiler Committee and the Advisory Committee for final proof-reading, on February 3, ten days before the Council meeting on February 13. At the Council meeting on this latter date at which the whole Boiler Committee was invited into conference, the report was approved by the Council in full, as finally revised, and was ordered to be printed as soon as possible for general distribution; and pamphlet copies are being issued as a preprint of the

Transactions of the Society. Following the approval of the report, action was taken by the Council commending the Boiler Committee and the Advisory Committee for the heroic work that it had carried out in such a painstaking and careful manner and expressing the gratitude and appreciation of the Society to the enlarged Committee for the great work it had done for mankind.

The next step taken by the Committee was a careful proof-reading of the entire report for typographical errors and the preparation of the Code for final printing. It is now being issued in pamphlet form as above mentioned, at \$1.00 per copy to members and \$1.50 to non-members. Later the Code will be distributed to the entire membership.

It is pleasing to note that the Code is finding immediate application. The State of Indiana is at this time considering the matter and it is very probable that an amendment will be passed by the legislature rendering the former Indiana boiler code optional, with the proviso that the A.S.M.E. Code may be used for boiler construction in place of the present State code if desired. The Ohio State Boiler Board has the new Code under consideration and it is possible that it will be adopted in place of the boiler code now in force in that state. In Wisconsin the Code will probably take immediate effect as a result of an action of the Industrial Commission of Wisconsin taken last year looking forward to the A.S.M.E. Code before it was completed; while a preliminary set of boiler rules was put into effect in that state the first of this year, provision was made for their replacement by the A.S.M.E. Code as soon as finished.

With the completion of this great work, considerable interest attaches to the originators of the movement, the committee of seven members, appointed in 1911. The choice of these members represents the exceptional wisdom and foresight of the officials of the Society in their concern that all the various branches of the industry should be represented. John A. Stevens, a consulting engineer of extended power plant experience who was appointed chairman, offered the advantages of his experience in formulating the Massachusetts code, the first state boiler code that was put into effect in this country. R. C. Carpenter and E. F. Miller, professors of engineering, came as representatives of the steam boiler users; E. D. Meier and Richard Hammond brought in the fund of experience that only long experience in boiler manufacturing rendered possible; Chas. L. Huston was particularly valuable to the Committee as a steel plate manufacturer and an investigator in the scientific manufacture of iron and steel plate, and Wm. H. Boehm, an insurance engineer, brought to the Committee valuable suggestions as a representative of the field of boiler inspection and insurance. The frontispiece shows portraits of the above members of the original committee.

## NOMINATIONS FOR OFFICERS OF THE SOCIETY FOR ELECTION IN DECEMBER 1915

The Constitution of the Society in C 47 provides among the Annual Committees:

> "A Nominating Committee appointed by the President."

It further provides in C 48

A "Special Nominating Committee: Twenty or more persons entitled to vote may constitute themselves a Special Nominating Committee, with the same powers as the Annual Nominating Committee."

The procedure in the nominations for office is provided in the following By-Laws:

B-27 "A Nominating Committee of five members, not members of the Council, shall be appointed before February first of each year by the President. The Secretary shall publish the names of this Committee in the March issue of The Journal together with a request to the voting membership of the Society that they recommend to the Committee the names of eligible persons for the elective offices to be filled at the next election. This Committee shall deliver to the Secretary in writing between the first and the fifteenth of June the names of its nominees for the various elective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of the Committee in the July issue of The Journal."

B-28 "A special Nominating Committee, if organized, shall on or before October fifteenth, present to the Secretary the names of its nominees for the elective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of this Committee in the November issue of The Journal."

The President has appointed the following Nominating Committee:

Messrs. Edwin M. Herr, *Chairman*
Fred J. Miller,
Richard H. Rice,
Walter M. McFarland,
Edward C. Jones.

There are to be elected in December next
A President to hold office for one year
Three Vice-Presidents to hold office for two years
Three Managers to hold office for three years
A Treasurer to hold office for one year

Under the terms of By-Laws B-27 and B-28 the voting membership are requested to send to either or both of the Nominating Committees, in care of the Secretary of the A.S.M.E., 29 West 39th Street, New York, N. Y., their recommendations of names for any or all of the elective offices to be filled at the next election.

*These recommendations should be sent in early and not later than June 1st.*

## COUNCIL NOTES

At a meeting of the Council on February 13, 1915, the Secretary reported the appointment by the President of the Nominating Committee for Officers for 1916, to consist of E. M. Herr, Chairman, Fred J. Miller, Richard H. Rice, W. M. McFarland and E. C. Jones. The Committee on Administration, referred to in these minutes in The Journal for January, was announced to consist of R. M. Dixon, Chairman, L. P. Alford, George M. Basford, George M. Forrest and J. W. Roe.

The appointment of Park A. Dallis as Honorary Vice-President to represent the Society at the inauguration of Edward Kidder Graham as President of the University of North Carolina was approved.

George I. Rockwood presented personally to the Council a letter of invitation to the membership of the Society to be present at the Fiftieth Anniversary of the foundation of Worcester Polytechnic Institute as a school of industrial science. The invitation was accepted by the members of the Council. The letter appears in this issue of The Journal.

The report of the Committee to Formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for their Care in Service was presented and approved with the following resolutions:

Resolved: that the report of the Committee to formulate Standard Specifications for the Construction of Steam Boilers and Other Pressure Vessels and for their Care in Service be received as presented in corrected galley proof and that it be printed in The Journal, and in the Transactions, and also in pamphlet form as part of the Transactions.

Voted: that the Boiler Code Committee and the Advisory Committee be continued for one year as one committee, instead of separated as formerly, and to be known as the "Boiler Code Committee."

The Council expressed its appreciation of the unprecedented amount of time and work which the various members had given to the preparation of this report and for the splendid results.

It was voted that the report of the Committee on Standards for Cross-Sections and Symbols be received and printed in the Transactions and that the committee be discharged.

It was voted to accept the report of the Committee on Special Threads for Fixtures and Fittings covering rolled thread screw shells, which was presented by the Secretary, and that it be printed in the usual way and come up for discussion at the next Spring Meeting.

It was voted to approve amendments to the By-Laws relating to the Nominating Committee for officers and a Special Nominating Committee. The text of these appears in this issue in the notice of Nominations for Officers of the Society.

The following appointments on local committees were approved: Committee on Meetings in St. Louis, Edw. Flad, Chairman, George R. Wadleigh, F. E. Bausch, E. R. Fish, E. L. Ohle; as additional members on St. Paul-Minneapolis Committee, Max Toltz and H. F. Mueller.

Calvin W. Rice, *Secretary.*

## SIR WILLIAM H. WHITE MEMORIAL FUND

The movement recently started by the leading engineers of England to erect a suitable memorial to Sir William H. White, the eminent engineer, has culminated in the appointment of a Memorial Fund Committee. This Committee has decided upon a memorial tablet with medallion portrait, to be erected in the building of the Institution of Civil Engineers in London, as one form in which honor to Sir William will be made manifest. The members of this Society will be given an opportunity to express their interest by contributing to the tablet fund, and a committee has been authorized by the Council to secure subscriptions. This committee consists of Jesse M. Smith, Alex. C. Humphreys and Frederick R. Hutton, and subscriptions may be sent to the Secretary.

## CONFERENCE ON SCREW THREAD TOLERANCES

On February 5, 1915, a large meeting was held in the rooms of the Society on the general subject of limits for the dimensions of the threads of screws and taps.

For more than two years this Committee of the Society, of which Mr. L. D. Burlingame is chairman, has been at work on the general subject of Tolerances For Screw Thread Fits, and the subject has had the detailed attention of a sub-committee consisting of Messrs. A. A. Fuller, Ellwood Burdsall and F. O. Wells. It was under the auspices of this sub-committee that the meeting of February 5 was called.

There were over forty in attendance, representatives of manufacturers of screws, taps and dies as well as the users, of such products and of organizations interested. A number of the largest firms in the country, both manufacturers and users were represented and also the engineering departments of both the Army and Navy.

Mr. Burlingame presided at the meeting. The committee had prepared an abridged report for distribution and there was a general discussion of limits of tolerances that would be recommendable with regard to pitch diameter, root diameter, outside diameter, lead and angle. Various opinions were expressed as to the desirability of specifying limits for more than one grade of work, i. e., a very close limit for the high grade of screw and a wide limit for screws to be used in rough work; also, whether differences in the specified limits should be made in the tap, or in the

screw. As a result of the conference, an Advisory Committee of three was appointed, consisting of Messrs. E. H. Ehrman, E. A. Darling and C. D. Young. This committee will confer from time to time with the regular committee upon the various questions which arise in this complex problem. Further, those who were in attendance at the meeting and others who have expressed their interest in the subject will be kept informed with regard to the progress of the work upon the report and, through their understanding of the situation as a result of the discussion at the meeting, should be in a position to render helpful suggestions.

This meeting is an example of the policy of the Society of conferring as widely as possible with representative men who are most vitally interested in any question affected by reports which are being formulated, with a view not only to securing the benefit of their experience, but the widest possible co-operation and unanimity of opinion. Meetings such as this tend to abolish misunderstanding and the consequent difficulties in establishing standards and greatly increasing the effectiveness of the work which the committees of the Society are accomplishing.

## FIFTIETH ANNIVERSARY OF WORCESTER POLYTECHNIC INSTITUTE

Worcester Polytechnic Institute, Worcester, Mass., is to be congratulated on having reached the point where it is to celebrate the 50th anniversary of the granting of the charter for the school. The celebration will occur on Wednesday, June 9, during the commencement period. It is expected that the President of the United States will be present and through the attendance of prominent engineers and the representatives of various organizations the day will be made a celebration of the achievements of engineering and science as well as an anniversary of the Institute.

At the February meeting of the Council of The American Society of Mechanical Engineers, Mr. G. I. Rockwood presented personally a letter of invitation to the Society which was accepted with pleasure and is herewith transmitted to the membership:

Worcester, Mass.
Feb. 12, 1915.

To the Council of
The American Society of Mechanical Engineers,
29 W. 39th St.,
New York.

Gentlemen:

On the 9th of next June the Worcester Polytechnic Institute will celebrate the 50th anniversary of its foundation as a school of industrial science. The Trustees and Faculty have constituted the undersigned members of the society, who are also graduates of the Institute, a special committee to invite most cordially all members to visit the Institute on that day.

There will be an opportunity to meet great engineers and great men. Among others, Colonel Goethals has accepted our invitation. The President of the United States, who was the commencement orator twenty-five years ago, has expressed a desire to be present. In addition to the academic and social events, a meeting of engineers is to be held, papers by members of the society will be read, and interesting processes of manufacture at various engineering works will be open to inspection.

Above all, however, there will be the chance to study the character and facilities of the Worcester Polytechnic Institute itself, to see its commercial shops, foundry and power house in operation and observe at first hand the methods of a unique experiment in engineering education which has continued for nearly half a century, having as its object the development of engineers who even in their youth are substantially prepared to share in the responsibility of handling commercial engineering problems.

The Institute really stands almost alone in providing its graduates with a practical training in the scientific management of industry, a subject discussed so often and so forcibly by the membership of this society. The student not only studies the kinematics and statics of machinery, and the nature of its parts, in the class room; the materials of construction in the chemical and physical laboratories; the thermodynamics of gases in the class room and engine room; but he performs work in commercial shops, foundry and power plant, on commercial machines, working factory hours alongside skilled mechanics. He not only hears lectures on the theory of business and shop management, but he handles and becomes familiar with such things as cash books, ledgers, time cards, pay rolls, shop reports, shipping receipts, balance sheets, and contracts. Different systems of time cards routing cards and cost systems can be tried out in the shops under real conditions, and the student becomes aware of every element of cost and of its relative importance in the price of an article of manufacture.

Men who have a natural ability for managing find after taking this course at Worcester that it has given them a tremendous start; that it has bridged for them the gap between their regular college course in "raw" engineering science, on the one side, and their practical usefulness, on the other. Their shop training work has been as near actual experience as it is possible for them to get.

It is commonly believed that such a mixture of theory and practice as this does not lend itself to courses of study in a professional school. The key, however, to success is the possession of adequate commercial shops within the direct control of the institution; and although the Department of Mechanical Engineering at Worcester provides all of the foregoing practical instruction in the regular course leading to the degree of B.S. in that department, it nevertheless does not fail to give as many hours devoted to pure physics, pure mathematics and those studies ordinarily called the humanities as are required by any other engineering school in this country; so that nothing in the way of high scientific attainment is sacrificed in order to secure time for these other no less important practical studies.

If the society's well known interest in the problem of modern scientific industrial education shall insure the presence of a large representation in June, it will add greatly to the success of the occasion.

| | |
|---|---|
| G. I. Rockwood, Chairman. | *Entertainment* |
| R. Sanford Riley | *Committee,* |
| Victor E. Edwards | *Am. Soc. M. E.* |

## SAN FRANCISCO MEETING

A meeting of the Society is to be held in San Francisco on September 16 and 17, in connection with the Pan-American Exposition which had its formal opening on February 15.

For the benefit of those who will attend a special train schedule will be arranged over the Southern Pacific. It is planned to pick up at New Orleans those members who will start from the Middle West or South and other points further West than New York.

According to the schedule as at present arranged, the

party will leave New York either Thursday evening, September 9, or Friday evening, September 10, and will stop at Niagara Falls, the Grand Canyon and possibly Colorado Springs. The Hotel Clift has been selected as the headquarters of the Society during the meeting.

An International Engineering Congress will be held in San Francisco from September 20 to 25.

## ADDITIONAL GREETINGS

The president of The American Society of Civil Engineers, Prof. Chas. D. Marx, lives in California and thus was unable to speak for his society at the meeting for establishing the Engineering Foundation. He had asked Mr. Clemens Herschel to represent the Society, who by misadventure was also prevented from attending, but who has sent in what, if present, he had intended to say. Mr. Herschel writes:

> I believe I convey to you the unanimous desire of our members, when, in their behalf, I am wishing a great future for the Engineering Foundation and am bringing a great measure of thanks to its founder.
>
> The Society appreciates the honor of being allowed to take a part in these exercises, and in the future administration of the Foundation. We here can say to the generous donor, paraphrasing what Latimer said to Ridley:
>
> "Be of good comfort, Master Swasey, we shall this day light such a candle, by God's grace, as I trust shall never be put out."

## APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i. e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before April 10, 1915.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Albin, Leland D., with Ingersoll-Rand Co., New York

Alcock, George W., Engrg. Dept., American Locomotive Co., New York

Bartlett, D. Dana, Cons. Engr., Sloan, Huddle, Feustel & Freeman, Madison, Wis.

Barr, Clarence D., Ch. Engr., American Cast Iron Pipe Co., Birmingham, Ala.

Bennett, Arthur N., Supt. Mfg. Dept., Safety Car Htg. & Ltg. Co., Jersey City, N. J.

Berggreen, Paul H., Librarian, Sibley College, Cornell University, Ithaca, N. Y.

Blair, George Jr., with McClave-Brooks Co., Scranton, Pa.

Brassington, John W., Engr. Drawing Room, The Pusey & Jones Co., Wilmington, Del.

Brown, Cecil W., Indus. Pwr. Specialist, Stone & Webster Mgt. Assn., Boston, Mass.

Browning, Earl H., first Vice-Pres., The Browning Co., Cleveland, Ohio

Butler, Thomas M., Genl. Foreman, Bauroth Mch. & Tool Co., and Toledo Barrel Co., Toledo, Ohio

Cheney, Frank, Jr., Pres., Cheney Bros., South Manchester, Conn.

Collins, Hubert E., Cons. Engr., Remington Typewriter Co., Utica, N. Y.

Cousins, George T., Mech. Engr. Rock Drill Dept., Ingersoll-Rand Co., New York

Czajkowski, Alexander, Ch. Draftsman, Byron Jackson Iron Wks., West Berkeley, Cal.

Davidson, John C., Ch. Engr., The S. S. White Dental Mfg. Co., Prince Bay, N. Y.

Davis, Charles B., Engr., C. B. Davis Engrg. Co., Birmingham, Ala.

Dickinson, Arthur R., Textile Rep., Lockwood, Greene & Co., Atlanta, Ga.

Diescher, Samuel E., Cons., Mech. and Civ. Engr., Pittsburgh, Pa.

Dodge, Horace E., Vice-Pres. and Genl. Mgr., Dodge Bros., Detroit, Mich.

Elder, Edward H., Cons. Engr., Springfield, Mass.

Elliott, William, Jr., Boiler Manufacturer, Leslie & Elliott Co., Paterson, N. J.

Fisher, Frances P., Asst. Genl. Mgr., Wichita Natural Gas Co., The Quapaw Gas Co., Arkansas Valley Gas Co., etc., Bartlesville, Okla.

Forbush, Franklin L., State Inspr. of Boilers and Examiner of Engrs., Commonwealth of Mass., North Adams, Mass.

Green, Walter H., Ch. Engr., International Filter Co., Chicago, Ill.

Halbfass, Arnold J., Asst. Engr., Gasoline Div., General Vehicle Co. Inc., Long Island City, N. Y.

Halyburton, Frederick J., Ch. Estimator, Taylor Wharton Iron & Steel Co., High Bridge, N. J.

Horner, Henry O., with the Horner Double-Acting Eng. Co., New York.

Hudson, Darwin S., Supvrg. Field Engr., Constr. Dept., Consolidated Gas Co. of N. Y., New York

Humphrey, Arthur L., Vice-Pres. and Genl. Mgr., Westinghouse Air Brake Co., Wilmerding, Pa.

Jones, Lewis, Assoc. Editor, "Power," New York

Kennicott, Cass L., Vice-Pres. and Genl. Mgr., The Kennicott Co., Chicago Heights, Ill.

Kimball, Dwight D., Cons. Engr. and Treas., Richard D. Kimball Co., New York

Knen, William E., Ch. Draftsman, Bureau of Water, Dept. of Public Wks., Philadelphia, Pa.

Knight, Ira D., Engr. Drive Chain Dept., Link-Belt Co., Chicago, Ill.

Knight, William A., Assoc. Prof. Mch. Shop Practice, Ohio State Univ., Columbus, Ohio

Koiner, C. Wellington, Genl. Mgr., Elec. and Mech. Engr., Pasadena Municipal Lt. & Pwr. Plant, Pasadena, Cal.

KREHER, ERNEST, Pres. Mech. Engr. and Genl. Mgr., Tampa Foundry & Mch. Co., Tampa, Fla.

LAW, OCTAVIUS A., Mech. Engr., The Midvale Steel Co., Philadelphia, Pa.

LAWRENCE, NORMAN S., Ch. Estimating Engr., Whiting Foundry Equipment Co., Harvey, Ill.

LESLIE, DAVID, Boiler Manufacturer, Leslie & Elliott Co., Paterson, N. J.

LEWY, DANIEL, Western Mgr., Standard Plunger Elevator Co., Chicago, Ill.

LOVELL, RALPH L., Cons. Engr. and Patent Expert, Quincy, Mass.

LYKE, HENRY W., Genl. Supt., Ames Iron Wks., Oswego, N. Y.

MCCABE, JOHN C., Ch. Boiler Inspr., City of Detroit, Mich.

MCCANN, FRANK G., Ch. of Heating and Ventilating Div., Board of Education, New York

MCGRAIL, FRANCIS J., Foundry Supt., Struthers-Wells Co., Warren, Pa.

MCNAMARA, THOMAS, Ch. Engr. and Master Mech., National Silk Dyeing Co., Paterson, N. J.

MACKINNON, Ch. Inspr., Compensation Inspection Rating Board, New York

MAKEPEACE, CHARLES R., Mill Architect and Engr., Providence, R. I.

MANTIUS, OTTO, Ch. Engr., and Vice-Pres., Zaremba Co., Buffalo, N. Y.

OLSON, LOUIS W., Supt. and Wks. Mgr., The Ohio Brass Co., Mansfield, Ohio

PARK, CHARLES F., Prof. of Mechanism, Massachusetts Inst. of Technology, Boston, Mass.

PARKER, THOMAS R., Supt. Eagle Wks., Standard Oil Co., Claremont, Jersey City, N. J.

PEACOCK, EDGAR A., Wks. Mgr., Fdy. and Mch. Shops, Atlantic, Gulf & Pacific Co., Manila, P. I.

PEASE, FRANCIS G., Astronomer, Mt. Wilson Solar Observatory, Pasadena, Cal.

PEASE, OSCAR D. A., Test Dept., Pennsylvania R. R. Co., Altoona, Pa.

PINKNEY, DAVID H., Ch. Draftsman, Pipe and Tube Mill Dept., The National Tube Co., Lorain, Ohio

POWER, WALTER J., Vice-Pres. and Efficiency Engr., The Emerson Co., New York

RAUSCH, JULIUS W., Mgr., Fly-Wheel, Sprinkler Leakage and Water Damage Depts., Maryland Casualty Co., Baltimore, Md.

REED, VAN A., JR., Treas., Federal Engrg. Co., Pittsburgh, Pa.

REYNOLDS, HERMAN W., Prof. of Mech. Engrg., and Cons. Engr., Univ. of the Philippines, Manila, P. I.

RICE, CYRUS W., Steam and Genl. Testing Engr., Atlantic Refining Co., Philadelphia, Pa.

SAALFRANK, JOHN M., Mech. Engr., DeLong Hook & Eye Co., Philadelphia, Pa.

SCHAUP, CHARLES E., Cons. Engr. and Ch. Engr., Lebanon Valley Cons. Water Supply Co., Harrisburg, Pa.

SCHIELDGE, GEORGE K., Supt., Taylor & Fenn Co., Hartford, Conn.

SCHNEIDER, RUDOLPH, Designing Engr., Busch-Sulzer Bros.-Diesel Eng. Co., St. Louis, Mo.

SHEPPARD, AULEY B., Dept. Head and Ch. Engr. Linoleum Dept., Armstrong Cork Co., Lancaster, Pa.

SIMPSON, ROSWELL H., Ch. Draftsman, Edison Laboratory, West Orange, N. J.

SLADER, WALTER, Mech. Engr., with John A. Stevens, Cons. Engr., Lowell, Mass.

SLOAN, ROBERT F., Genl. Mgr., Charlevoix Rock Product Co., Charlevoix, Mich.

STANNARD, JAMES M., Mgr., Chicago Office, American Steam Pump Co., Pres. and Treas., Stannard Pwr. Equipment Co., Chicago, Ill.

STEVENSON, WILLIAM H., Secy., Power Plant Specialty Co., Chicago, Ill.

STOLBRAND, VASA E., Headmaster, Shattuck School, Inc., Faribault, Minn.

STONE, DWIGHT G., Secy., Sprinkler Leakage & Fly Wheel Depts., The Aetna Accident & Liability Co., Hartford, Conn.

STORMS, FRANK F., Pres., Page-Storms Drop Forge Co., Chicopee, Mass.

STUBBS, FREDERICK W., Mech. Engr., Chicago Great Western R. R. Co., Oelwein, Ia.

THOMPSON, JOHN R., Senior Mech. Engr., Interstate Commerce Commission, Chicago, Ill.

VATER, FRANK F., Pres., Power Plant Specialty Co., Chicago, Ill.

VERHEY, HUBERT C., Ch. Designing Engr., Marine Eng. Dept., Busch-Sulzer Bros.—Diesel Engine Co., St. Louis, Mo.

WALDRON, J. LAURENCE, Inspr., Testing Bureau, Transit Development Co., Brooklyn, N. Y.

WASHBURN, JOHN E., Mech., Engr. and Asst. Master Mech., National Carbon Co., Cleveland, Ohio

WHITE, D'ORSAY MCC., Engr., The Cadillac Motor Car Co., Detroit, Mich.

WILDE, JOHN R., Ch. Engr. of Pwr. Plants, The Edison Ill. Co., Detroit, Mich.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ARNSTEIN, LEONARD A., Supt., Imperial Metal Mfg. Co., Long Island City, N. Y.

AVERY, A. ORDELL, Head of Sect., Layout Dept., Western Elec. Co., Chicago, Ill.

BEAMAN, PHINEAS A., Mech. Engr., Willett, Sears & Co., Boston, Mass.

BIDDISON, PASCAL MCD., Constr. Engr., Ohio Fuel Supply Co., Columbus, Ohio

BOWLES, WILLIAM A., JR., Engr., Constr. Dept., Appalachian Pwr. Co., Bluefield, W. Va.

BURROWS, GROVER C., Civil Engr., C. W. Blakeslee & Sons, North Branford, Conn.

CAMPBELL, JAMES A., Mech. Supt., Renfrew Mfg. Co., Adams, Mass.

CLUCAS, GEORGE W., Engr., Chicago Office, American Steam Pump Co., Secy., Stannard Pwr. Equipment Co., Chicago, Ill.

EGBERT, HARRY D., Asst. Engr., The Research Corp., New York

ELMER, NIXON W., Engr., The Lamson Co., Boston, Mass.

GIBBS, GEORGE W., Jr., Manufacturer, Gibbs Gas Eng. Co., Jacksonville, Fla.

HAAS, HARRY A., Cartridge Designing, Winchester Repeating Arms Co., New Haven, Conn.

HOBBS, GEORGE W., Instr. in Engrg., Univ. of Wisconsin, Madison, Wis.

HOLCK, HARRY C., Draftsman, Public Service Elec. Co., Newark, N. J.

JACK, RICHARD D., Engr., Clinton H. Scovell & Co., Boston, Mass.

KLOCKE, JOSEPH F., Designer, E. W. Bliss Co., Brooklyn, N. Y.

WHITE, KENNETH, Engr., By-Products Coke Corp., Chicago, Ill.

SUMMARY

New applications .................................... 101

# IRON AND STEEL SESSION

*SIMULTANEOUS with the afternoon session of the Public Service meeting, a professional session was held devoted to iron and steel topics. Three papers were presented followed by a topical discussion on alloy steels and kindred subjects. The meeting was unusually successful as it was well attended and continued for over three hours. The papers presented were as follows: Factors in Hardening Tool Steel, John A. Mathews and Howard J. Stagg, Jr. (Contributed by the Sub-Committee on Iron and Steel); Standardization of Chilled Iron Crane Wheels, F. K. Vial (Contributed by the Sub-Committee on Hoisting and Conveying); and The Mechanical Elimination of Seams in Steel Products, Notably Steel Rails, R. W. Hunt.*

## FACTORS IN HARDENING TOOL STEEL

BY JOHN A. MATHEWS, SYRACUSE, N. Y.

Member of the Society

and

HOWARD J. STAGG, JR.,[1] SYRACUSE, N. Y.

Non-Member

The paper is devoted primarily to the practical side of the art of hardening and tempering tool steel, carbon steels being considered in the first place (0.60 to 1.50 per cent carbon).

The authors explain at some length the structural variations of steels as a function of carbon content and temperature, as well as the influence of the critical ranges of temperature on the properties of steel, with particular attention to volume changes (variation of expansion with temperature). In case of overheating, the first cooled portion is hardened first, forming an unyielding shell, and a strain is set up by the slower cooling interior which may lead to cracks and ruptures.

*Time of Heating.* The time of heating is of extreme importance for the strength of the piece: if the heating is too fast, the temperature through the piece will not be uniform, while long heating leads to the formation of abnormal size of grain and weakness of the metal. A very bad practice is quick heating in a furnace which is considerably hotter than the correct hardening temperature. The difficulty is that the thin parts, corners, and edges are liable to attain an overheated temperature before the larger portions of the piece attain the correct hardening temperature, and this overheating of the thin parts produces large grain size, abnormal expansion and tends to produce cracks.

*Speed of Quenching.* The metal must be cooled quickly, so as to obtain martensite, which is the correct constituent of hardened steel. The authors illustrate the influence of quenching by two examples which however are not tool steels, and after mentioning, according to Benedicks,[2] the conditions which a liquid must have to exhibit a good quenching power, proceed to report their own tests of various quenching media which included pure water, brine solutions, and various oils. The results obtained are expressed in the form of curves.

In attacking the problem, the following method was adopted: A test piece of the dimensions shown in Fig. 1 was machined from a solid bar, and a hole drilled through the neck to within an equal distance from each side and bottom of the test piece. Into this hole a calibrated, platinum-rhodium couple was inserted and the leads connected to a calibrated galvanometer. The test piece was then immersed in a lead pot, also containing a thermo-couple to the point $A$, and the lead pot was maintained at a temperature of 1200 deg. fahr. When the couple inside the test piece was at 1200 deg. fahr., and the couple in the lead pot read 1200 deg. fahr., the test piece was removed and quenched to the point $B$ in 25 gal. of the quenching medium under consideration. At the start the quenching medium was maintained at room temperature. The time in seconds that it took the test piece to fall from a temperature of 1200 deg. fahr., to a temperature of 700 deg. fahr., was noted by the aid of a stop-watch. It is clear that immersing the test piece in the quenching medium raised the temperature of the medium. The test piece was then replaced in the lead, heated to 1200 deg. fahr., quenched into the medium at this higher temperature and the time again taken with the stop-watch. These operations were continued until the quenching media, in the case of oils, had attained a temperature of about 250 deg. fahr. The results obtained, time in seconds, for a fall from 1200 deg. fahr. to 700 deg. fahr., were plotted against the temperature of the quenching medium and a series of curves as shown in Figs. 2 to 8 inclusive were obtained.

A consideration of the results is interesting. Pure water (Fig. 2) has a fairly constant quenching rate up to a temperature of 100 deg. fahr., where it begins to fall off. At 125 deg. fahr., the slope is very marked. Brine solutions (Fig. 2) have both a quicker rate of cooling and are more effective at higher temperatures than water. The curve does not begin to fall off seri-

[1] Halcomb Steel Co.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to non-members.

[2] Journal of the Iron and Steel Institute, 1908, II., p. 212.

ously until a temperature in the neighborhood of 150 deg. fahr. is reached. Where water at 70 deg. fahr., cooled the test piece in 60 sec., the brine solutions cooled it in 55 sec.

Oils are slower in their quenching powers than water or brine solutions, but the majority of them have a much more constant rate of cooling at higher temperatures.

The curves shown in Figs. 7 and 8 are for thick viscous oils somewhat similar to cylinder oils. These curves are particularly interesting in that they have slower quenching abilities at low temperatures than at higher temperatures.

A comparison of curves in Figs. 4 and 5 shows the variation in quenching power of the same oil due to continued service. The differences in quenching rates may well account for different results from the same steel in different shops, or in the same shop due to change of oil used.

*Hardness as Affected by Mass.* Figs. 9 to 12 inclusive show results from quenching different masses of the same material under like conditions. Test pieces 4 in. long were made from the same ingot in sizes increasing 1/8 in. in breadth and thickness. The smallest was 3/8 in. square and the largest 3 1/4 in. square. Three ingots of different analysis were shown and a series of test pieces made from each. The test pieces were heated in a semi-muffle furnace to a constant temperature quenched, and the Brinell hardness test made. Each series was then drawn to 600 deg. fahr. in a salt bath and Brinell tests again taken and then reheated to 1200 deg. fahr. in a salt bath and Brinell hardness tests again run.

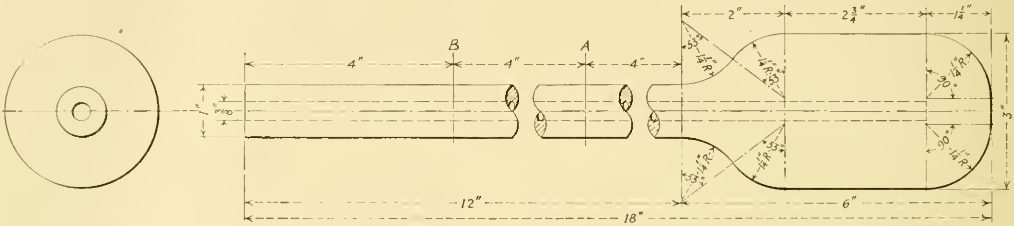



FIG. 1 TEST PIECE USED IN QUENCHING TESTS

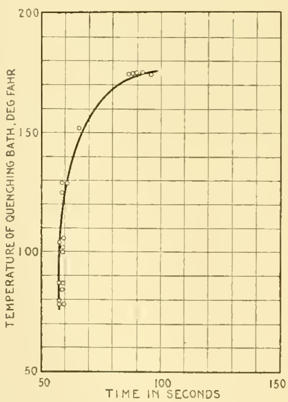



FIG. 2 QUENCHING POWER OF SYRACUSE CITY WATER

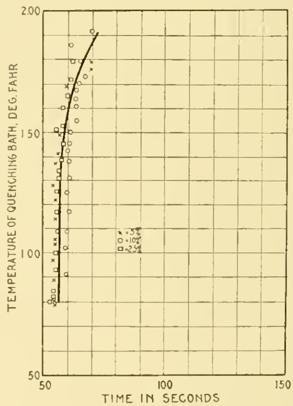



FIG. 3 QUENCHING POWER OF BRINE SOLUTIONS

It will be noted that the smaller the sample the greater the figure of hardness, indicating that the smaller sections are cooled with greater rapidity than the larger. The same agencies are at work in tool steel. The larger the mass the smaller the depth of hardness when quenched under similar conditions. In order to produce the same amount of hardness in a small and large section it is necessary to heat the larger section hotter than the smaller. A commercial application of this phenomenon will perhaps be interesting. The authors were recently confronted with the

problem of finding out the correct temperature for hardening tools made from the same steel in sizes varying from $\frac{1}{16}$ in. diameter to $\frac{3}{4}$ in. diameter. The temperature-size curve shown was finally adopted (Fig. 13). In other words, a $\frac{3}{16}$ in. round will harden at 1395 deg. fahr., while a $\frac{3}{4}$ in. round bar should be heated to 1450 deg. fahr.—a difference of 55 deg. fahr.

*Time and Degree of Drawing Temper.* After the hardening operation has been safely performed, the next important step is that of drawing the temper. This operation is necessary for two important reasons:

*a* The relieving of abnormal strains set up due to the quick contraction or expansion.

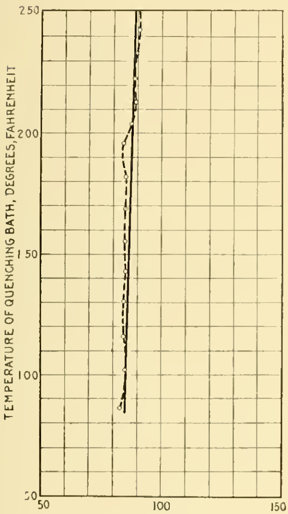



Fig. 4 Quenching Power of No. 2 Lard Oil

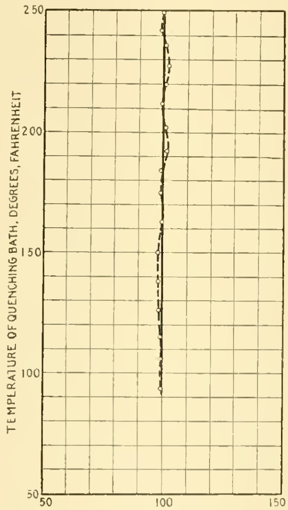



Fig. 5 Quenching Power of Prime Lard Oil in use Two Years

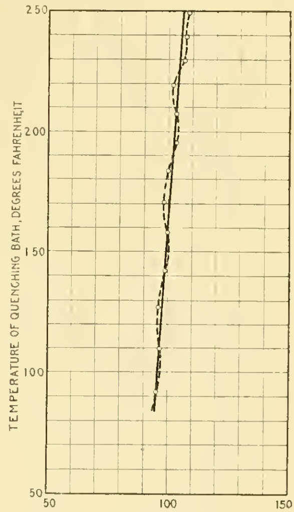



Fig. 6 Quenching Power of Raw Linseed Oil

*b* The breaking down of the extremely hard and brittle structure of the quenched steel.

The drawing of the temper begins to break down the true martensitic structure and as the temperature increases there are formed intermediate micro-structures between martensite and pearlite, first troostite, then sorbite, and finally pearlite.

Professor Heyn has published some valuable results on the decrease of hardness on tempering. The results are expressed in per cent of the original hardness.

| | | | |
|---|---|---|---|
| 100 deg. cent... | 2.5 per cent. | 400 deg. cent... | 70 0 per cent. |
| 200 deg. cent. . | 14 0 per cent. | 500 deg. cent. | 87 5 per cent. |
| 300 deg. cent. | 41 0 per cent. | 600 deg. cent.. | 97 5 per cent. |

Regarding the effect of time on drawing the temper, standard $\frac{1}{2}$ in. round A.S.T.M. test pieces were quenched from constant temperature into the same medium, and the temper drawn in same salt bath at constant temperature for five minutes, fifteen minutes, etc.

| Elastic Limit | Maximum Strength | Elongation | Reduction | Brinell | Remarks |
|---|---|---|---|---|---|
| 228,750 | 260,137 | 2.5 | .... | 425 | 1550-oil-800 deg. fahr. 8 min. |
| 201,125 | 214,562 | 11.6 | 45 4 | 390 | 1550-oil-800 deg. fahr. 20 min. |
| 175,000 | 183,187 | 12 | 49.35 | 340 | 1550-oil-800 deg. fahr. 40 min. |

A study of the table shows that time at the drawing temperature has a marked effect. The act of breaking down the martensite is progressive and not sharply defined. Both time and temperature have their effects.

The greater the initial hardness of the piece, the more marked is the effect of drawing the temper. By referring to Figs. 9 to 12 inclusive the actual values in Brinell hardness are shown. The piece of 0.25 carbon nickel, $\frac{5}{8}$ in. sq., quenched in oil, shows a Brinell of 360; drawn to 1200, a Brinell of 223. The per cent decrease in hardness is 61. The piece of $3\frac{1}{4}$ in. sq., quenched shows a Brinell of 208; drawn to 1200 deg. fahr., Brinell 183, showing a decrease in hardness of only 13 per cent.

Many years ago, one of the authors made several hundred hardening experiments and several thousand measurements to study the change of shape. The materials used were cylinders of steel and taps. Crucible steel alone was examined and the following variables were considered: (*a*) the effect of original form or

diameter upon the diameter after hardening; (*b*) the influence of carbon on change of form; (*c*) the influence of initial temperatures at quenching; (*d*) the influence of length of time of heating; (*e*) the influence of repeated hardenings, and (*f*) the effect of annealing previously hardened steels, upon change of shape in rehardening. Obviously when plain cylinders of steel are considered, there are four possible changes of shape, expansion in length and diameter, contraction in length and diameter, expansion in length and contraction in diameter, and contraction in length with expansion in diameter.

Under the influence of the variable conditions mentioned above, all four changes were actually produced. Steel was also found which expanded in length on first hardening and contracted indefinitely thereafter on repeated hardenings. Another steel expanded in length on two hardenings and contracted on the next two. In a variable carbon series of steels from 0.50 to 1.33 per cent carbon, the magnitude of the change in length after four hardenings, increased as the carbon increased. For the same series it was noted that the volume changes were greater when hardening annealed rather than unannealed bars. The increase in length is greater the higher the hardening heat for all carbons.

These tests emphasize the fact that variable conditions produce variable results. It is of vital importance that steel be furnished uniform, chemically as well as physically, and it is equally important that the user employ every possible refinement in the handling of his product. It is only under varying conditions of heat, size, time, composition, etc., that the results vary. Different steels will not behave alike in all cases, but it is a simple matter to determine under any given set of conditions how a particular steel will behave. Other things being equal, therefore, the original composition, grain size, condition of annealing and the method of manufacture affect the resulting changes in form after hardening. Above the decalescence point, the coefficient of dilatation increases proportionately with the carbon and for all carbon percentages the rate of dilatation increases with the temperature. Resulting changes of form are conditioned by the original proportions of the piece quenched, by its chemical composition, by the temperature from which it is quenched, and within certain limits by the time of heating. Hardness, brittleness, change of form and liability to crack, generally speaking, increase with the carbon content and the temperature and time of heating. Nevertheless, constant conditions give constant results.

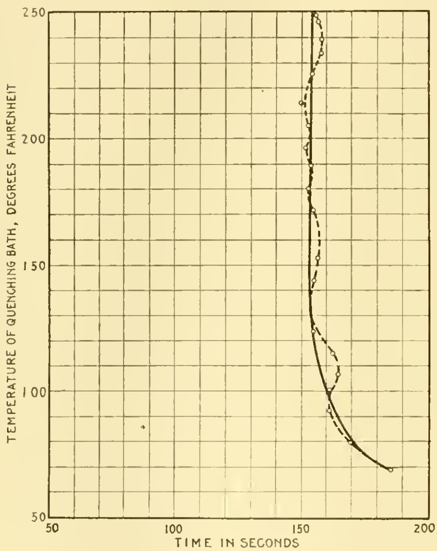



Fig. 7 Quenching Power of No. 1 Dark Tempering Oil

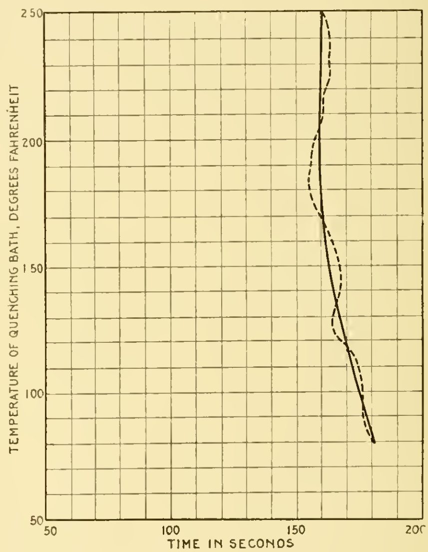



Fig. 8 Quenching Power of Special "C" Oil

Constant conditions are not always attainable. The maker of steel cannot control conditions in his customer's shop and the customer cannot control conditions in the steel plant, and the human element must be considered in both. The properties described are inherent properties of carbon steel, and because of them many a dispute has arisen over tools lost in hardening. The placing of the exact responsibility is very difficult.

*Furnaces and Methods of Heating.* Much has been

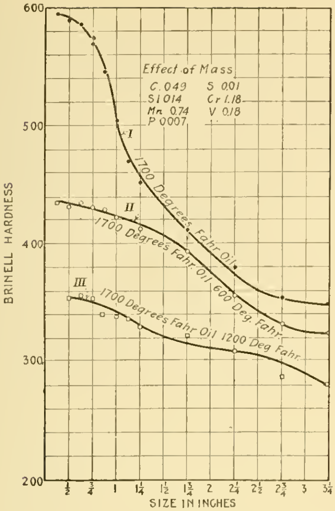



FIG. 9

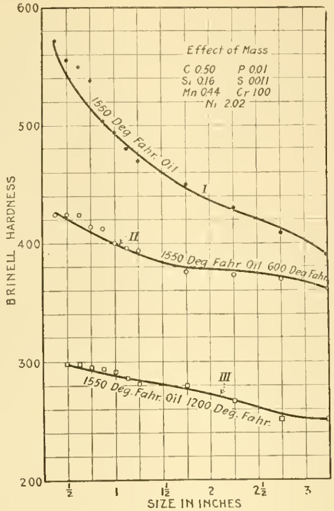



FIG. 10

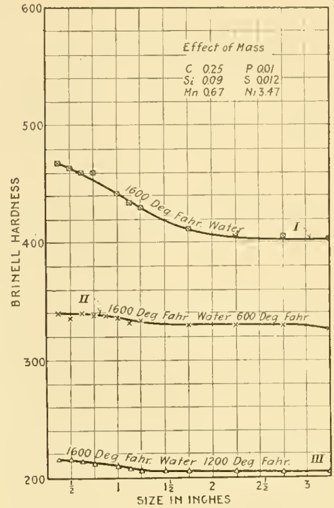



FIG. 11

BRINELL HARDNESS OF TEST PIECES AFTER QUENCHING TO SHOW EFFECT OF MASS

said regarding the superiority of gas furnaces over oil furnaces and vice versa. The fuel used is immaterial for good practice so long as the following points are taken care of:

*a* The furnace and hearth should be of sufficient size so as not to be affected materially in temperature by the introduction of the parts to be hardened.

*b* The furnace should heat at a uniform rate.

*c* The furnace should be of uniform temperature over its entire hearth.

*d* The furnace should be run under neutral, or reducing conditions. A good rough test for this is the introduction of a piece of wood or paper upon the hearth. If the paper, or wood, burn, the atmosphere is oxidizing. If they char, reducing or neutral.

*e* The temperature control must be at all times exact and it must be possible of exact duplication on repetition work.

A blacksmith's fire is satisfactory under good handling, but for constant work it is too exacting on the operator and requires too many manipulations to secure uniform and continuous results. To expect uni-

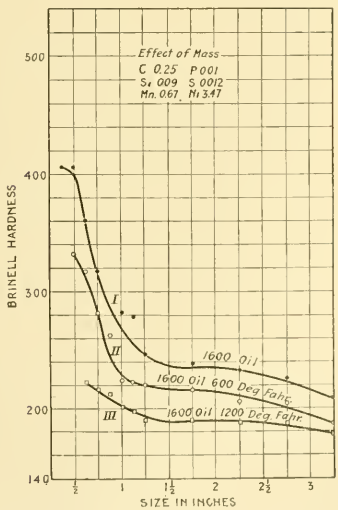



FIG. 12 BRINNELL HARDNESS TO SHOW EFFECT OF MASS

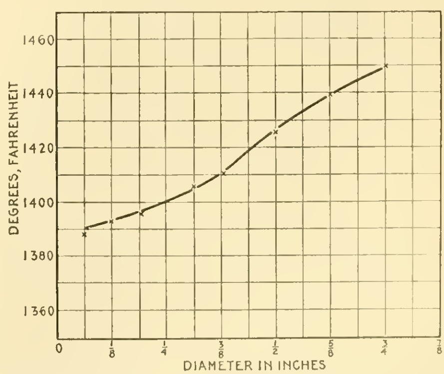



FIG. 13 TEMPERATURE—SIZE CURVE FOR HARDENING TOOLS

formly good and consistent results from a hardener not provided with adequate or suitable equipment is unreasonable. When the question of good equipment in the way of furnace, quenching arrangements and media, pyrometers, etc., has been satisfactorily taken care of, the hardener still has plenty of variables to contend with which are beyond his control.

## DISCUSSION

HENRY M. HOWE[1] in a written discussion particularly endorsed the use by the authors of their ingenious method of determining the rate of cooling of different liquids, a method which can be applied without the use of sensitive instruments, and is superior to that of Benedicks.

With reference to carbon, it should be understood that the pearlite and the excess of ferrite and cementite referred to are not always recognizable under the microscope. Under certain conditions they are apt to be all mixed in such a fine emulsion (called "sorbite") that they cannot be recognized individually.

Referring to the position of the critical temperature in carbon steels, it should be understood that the influence of manganese and nickel in lowering the transformation range is primarily through their increasing the hysteresis. When the decalescence points are determined, it is found that they have not been very greatly lowered, while the observed lowering of the recalescence point represents chiefly hysteresis.

Further, the writer indicated several additional authorities, especially the work of Benedicks, and approved of the results given in Table 1 on the penetration of hardness. In reality, the hardness of the corners and edges exceeds that of the interior of the piece even in a greater degree than these numbers would indicate, for the reason that when the Brinell ball is pressed into the specimen near its edge, and more particularly near its corner, its indentation is abnormally great because of the proximity to the side of the piece.

Figs. 9 to 12 indicate that our previous belief as to the completeness of annealing at 600 deg. cent. was incorrect, thus showing that what Goerens found for very low carbon steel, does not hold for hardening caused by rapid cooling. Similarly, the results in the table which show that at 430 deg. cent. the tempering was very far from reaching the maximum for that temperature even after a sojourn of 20 minutes, disagree with the earlier and very precise determinations of Barus and Strouhal who found that the tempering at these temperatures reached its maximum very quickly. One is at first tempted to refer the softening observed after the 20 minutes and the 40 minutes exposure of the authors to opportunity for coalescence of the sorbite, but it seemed to the writer that the loss of elastic limit and hardness is too great to be accounted for in this way.

J. J. RALPH in a written discussion called attention to the experiments on cylinders which expanded or contracted in length or cross-sectional area or both. The results coincide with some experiences of the writer with hypo-eutectoid steels of about 0.45 per cent carbon.

Finished pieces about 2 in. in diameter with 0.001 in. tolerance showed differences as much as 0.002 in. above high to 0.002 in. below low limit after hardening. It being quantity production, this was obviously very expensive, requiring either the scrapping of the piece or costly finishing of extremely hard surfaces. Closer observation showed it to be the result of variations in quenching temperatures. This pointed to a temperature at which the steel could be hardened and at which it would neither shrink nor expand. Instructions were given to the machine shop to hold the piece as closely as possible to the high limit and suitable care being given, 90 per cent was finally going direct through inspection to assembly. Further investigation showed that the facilities for measuring temperature were not delicate enough to allow the fine control necessary. Nor could it be sure that the steel was running evenly enough chemically (it was a low price openhearth low carbon, low phosphorus and sulphur) to allow the fixing of a definite range. Quenching conditions, both as to composition of the quenching material and its temperature were far from ideal, thus giving three variables which were unknown.

A case has come to light where this ideal was reached. The steel was about 0.6 per cent carbon. It involved control of temperature to within a total range of less than 5 deg. fahr. considerably less than the instrument error of the best of indicating pyrometers and was only made possible by the use of a bath furnace and the resistance thermometer.

Skilled practical men, knowing the steel they are working with, are willing to guarantee almost a finished hardened piece exact to size and shape. A comparison of results obtained by several skilled smiths will show a surprising difference, probably owing to different kinds of steel they have been accustomed to handling. It must not be overlooked that the usual hardening room and machine shop conception of "exact" is far from perfect.

Investigation of hardening defects is not usually as thorough as it should be. It is hampered by ignorance of past conditions and the effect of previous operations, lack of knowledge of the steel used, human elements of feeling as to the money involved, responsibility, and a feeling that steel is steel and does what it does. Seldom is an attempt made to reproduce the defect thus proving conclusively what the cause was.

In his own work on long relatively slender pieces, the writer found most of his trouble in distortion due to bending in heating. Steel when hot seems to bend under the application of a steady, even, though slight load, the weight of the part being hardened often being sufficient to cause very noticeable distortion. Another case is initial condition of strain, either due to forging, rolling, machining or accident. When the bar is heated, the strains are relieved and there is a bending or twisting of the piece in readjustment. These are particularly annoying in fine work and in one case the substitution of square for round stock eliminated this trouble in a round machined piece.

If a practical way could be found to hold hardened pieces to size and shape, it would be possible to do all of the machining with the piece soft. A very material shop saving would be obtained and it would also allow the use of parts with physical characteristics as we would like to have them instead of makeshifts in many places. The problem has been simplified within the past year by the introduction of the potentiometer type pyrometer with a possible commercial accuracy in skilled hands of about one deg. fahr.

[1] Columbia University, New York.

O. R. Cary[1] stated that he had occasion to produce a number of die blocks of the average size of 5 by 3 by 1 in. These were treated in an electric resistance furnace. It was found that if a certain size was heated in 44 minutes to the proper point, as indicated by the passage of that piece through the transformation point by about 20 or 25 deg., a die was obtained which required no further chemical treatment. A cut of less than a thousandth of an inch cleared it perfectly. If it was heated in 38 instead of 44 minutes, a cut of at least four-thousandths was required to clear the surface, with similar changes in shape. This period of 44 minutes happens to be the constant for this particular furnace; for some other furnace it undoubtedly would be different. But it has been proved that if you vary the point of heating ordinary carbon commercial steel by as much as 5 per cent, you have varied the shape of your piece perceptibly.

A great many of the troubles in the treatment of such masses of metal have been laid either to steel or to pyrometers.

Bradley Stoughton expressed his appreciation of the paper and said that if it should result in reducing to a science some of the rules of thumb with which steel tempering men are accustomed to work, it would be a great help. He was particularly interested in the experiments outlined on the effect of mass. Those who have tempered large pieces of steel have noticed one difficulty which occurs occasionally, particularly in dies. If the die is large so that the mass of the metal is considerable there is liable to be a soft zone of metal immediately under a very hard exterior so that the die will frequently drop, as they call it. This has undoubtly been explained by the author and by Professor Howe. The exterior of the metal cools and shrinks in the interior; then the interior in its cooling shrinks away from the hard exterior which will naturally produce a zone of soft metal. He hoped that the author and his associates might throw some light on a better quenching medium for steel of large mass.

John A. Brashear by way of illustration of the extreme refinement required in the treatment of steel in order to secure homogeneous material, said that 10 or 15 years ago he was asked to make a rotating mirror to determine not only the velocity of light, or redetermine it, but for the purpose of determining the variation of the speed of the various wave-lengths, if possible. The mirror was to rotate some 30,000 revolutions per minute and its four sides had to be located so that they were absolutely equi-angular with the surfaces. The image of a star thrown on the surface of one of the sides had to go about three miles away and then come back without being distorted, which illustrates the extreme accuracy required. Not only was great difficulty experienced in the mechanical problems involved, but also in getting homogeneous surfaces of a standard quality of hardness so that each surface would polish the same. If one spot on the surface was a tiny little bit different from any other spot, the surface would be a little low where it was softer and a little high where it was harder. The work, however, was finally accomplished and the mirror has been used for making a number of light determinations.

The Authors answered numerous inquiries during the discussion regarding various points in the paper upon which further information was desired. Mr. Stagg in response to the request of the chairman for a topical discussion upon alloy steels supplementing the information given in the paper, showed a number of interesting lantern slides of microphotographs of alloy steel and explained their characteristics.

[1] Leeds and Northrup Company, Philadelphia.

# STANDARDIZATION OF CHILLED IRON CRANE WHEELS

BY F. K. VIAL,[1] CHICAGO, ILL.

Non-Member

This paper presents the results of an extended investigation of the whole subject of chilled iron wheels for cranes. Because of the great quantity of summarized and tabulated data which the paper contains, it is not possible to prepare a comprehensive abstract to come within the space available. What follows, therefore, is in the nature of a synopsis of the paper.

In the earlier stages of crane construction, wheels of the general design used in railroad service were adapted to crane service by adding a second flange of about the same section as that of a railroad wheel. This practice worked very well as long as the wheel loads did not exceed those used in railway service. In the heavy types of bridge cranes, however, concentrated wheel loads five times as great as occur in railroad service are required to secure the greatest economy.

The most common troubles with crane wheels are:

*a*. Wheels becoming out of round on account of unequal wear.

*b* Breaking down of metal on account of loads exceeding its bearing power

*c* Distortion and binding of flanges on account of irregularity in gage of track.

*d* These defects in wheels produce heavy strains throughout the structure, including worn and broken propelling gears.

All of these defects are not only annoying but expensive on account of the interruption of service of important machinery.

The Griffin Wheel Company has undertaken an investigation into these various phases by testing to destruction a large number of full size wheels of various designs in the R. W. Hunt & Company's 300,000-lb. Riehle testing machine. Use was also made of a considerable number of tests made at Purdue University and at the University of Illinois.

The items established are:

*a* The relation of the bearing power of chilled iron, to various types of steel rails.

[1] Griffin Wheel Co.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 20 to members; 40 cents to non-members.

*b* The carrying capacity of various rails.
*c* The relation of the diameter of wheel to traction.
*d* The relation of diameter of wheel to flange strength.
*e* The relation of flange thickness and tread thickness to flange strength.
*f* Standardization of designs for all diameters of crane wheels.

*Bearing Power of Chilled Iron on Steel Rails.* The vertical load to be carried on any wheel is not limited by the capacity of the wheel, but by the carrying capacity of the rail. The bearing power of chilled iron

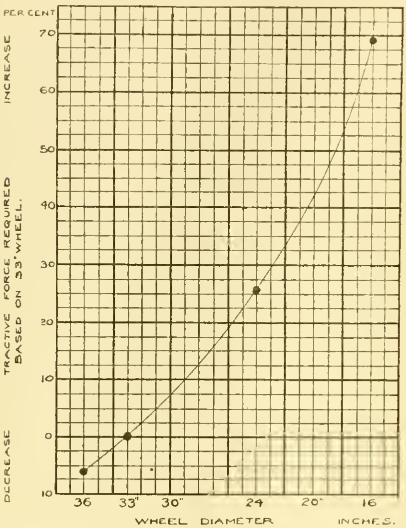



Fig. 1 Percentage of Tractive Force required for Various Diameters of Wheels compared with 33-in. Chilled Iron Wheels

is far in excess of that of a steel rail, and, therefore, may be neglected when considering maximum vertical loads.

The tests show that under like loads, the depression in the rail is inversely as the diameter of the wheel. The larger diameter of wheel makes a larger area of contact, which reduces the pressure per square inch.

The following table shows that the mean intensity of the stress over the area of contact was about 100,000 lb. per sq. in. for the chilled wheel and 86,000 lb. for the steel driver.

*Analysis of the Carrying Capacity of Various Rails.* Tables are given to show that on a new A.S.C.E. rail the safe maximum limiting load for a 12-in. wheel is 23,000 lb., and for a 33-in. wheel, 38,150 lb. If the top of the rail is flat, 2 in. wide, the limiting load on 12-in. wheels is 78,300 lb. and on 33-in. wheels, 130,000 lb. One of the tables gives also the carrying capacity

TABLE 1 CONTACT AREAS AND PRESSURES

| Load in Lb. | 33-In. Chilled Wheel | | 44-In. Steel Driver | |
|---|---|---|---|---|
| | Contact Area | Pressure per Sq. In. | Contact Area | Pressure per Sq. In. |
| 5,000 | 0.07 | 71,500 | 0 07 | 71,500 |
| 10,000 | 0.12 | 83,300 | 0 15 | 66,700 |
| 15,000 | 0.16 | 93,750 | 0 19 | 79,000 |
| 20,000 | 0.22 | 90,900 | 0.25 | 80,000 |
| 25,000 | 0.27 | 92,600 | 0 30 | 83,300 |
| 30,000 | 0.35 | 85,750 | 0 36 | 83,300 |
| 40,000 | 0.40 | 100,000 | 0 47 | 85,000 |
| 50,000 | 0.44 | 113,600 | 0.50 | 100,000 |
| 60,000 | 0.57 | 105,000 | 0.68 | 88,300 |

of the rail only, without reference to the strength of the wheel.

*Relation of Diameter of Wheel to Traction.* The power required for locomotion decreases as the diameter of wheel increases.

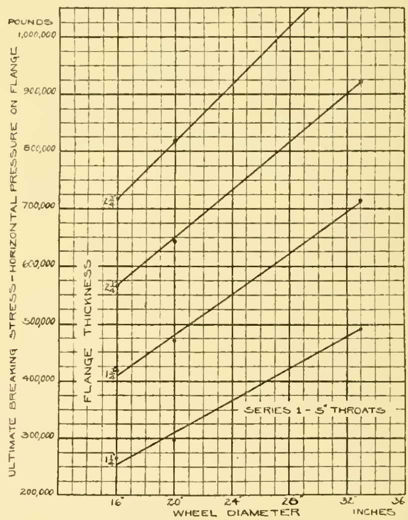



Fig. 2 Curves showing effect on Flange Strength produced by Increase in Wheel Diameter

A 24-in. wheel requires 25 per cent more power than a 33-in. wheel.

A 16-in. wheel requires 68 per cent more power than a 33-in. wheel.

Fig. 1 shows graphically the relation between the variation in the diameter of wheel, and tractive force required. It appears that the 24-in. wheel would require 25 per cent more power and the 16-in wheel 68 per cent more power than the 33-in. wheel under these conditions.

As regards the safe loads and deflections of rails. From the bearing tests made, the average depression due to bearing alone was 0.0029 in. per 10,000 lb. load:

$$0.0029 \times 13.7 = 0.0397$$

Combined deflection and depression, 0.0497.

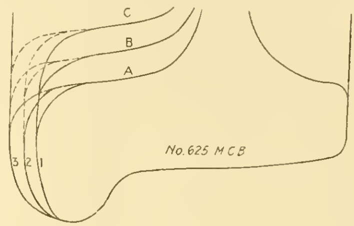
*Relation of Diameter of Wheel to Flange Strength.* The strength of flanges increases with the increase in diameter of wheel. With the same dimensions of flange and tread the flange on a 33-in. wheel is from 26 per cent to 34 per cent stronger than the flange on a 24-in. wheel and from 62 per cent to 92 per cent stronger than the flange on a 16-in. wheel.

The failure of wheels occurred in what may be called two stages. The first failure represents the ultimate strength of the chilled or white iron. The ultimate failure represents the rupture of the grey iron. The coefficient of elasticity is evidently different in the two kinds of iron, and the necessity for backing up the chilled iron with grey iron is clearly indicated. The curves in Fig. 2 show that from the 1¼-in. flange to the 2¾-in. flange, the rate of increase in strength is higher with each successive flange thickness.

*Relation of Flange Thickness and Tread Thickness to Flange Strength.* The tests show that the relation of flange thickness to throat thickness for crane wheels should be as two is to three. Assuming the strength of a flange 1¼ in. thick and throat thickness of 1⅞ in. as 100, a flange having a thickness of 1¾ in. and throat thickness of 2⅝ in. would be 200. In other words, every ⅛ in. added to flange thickness with the relative increase in throat thickness increases the flange strength 25 per cent. Chilled iron flanges were tested to above 1,000,000-lb. horizontal pressure without breaking.

The value of chilled iron for wheels to carry the heaviest concentrated loads is being more and more recognized. This is shown in crane work and other locations where loads of 100,000 lb. and upwards are required per wheel. An inquiry from a U. S. Navy Yard for 38-in. wheels for use under a heavy traveling crane reads as follows: "The steel wheels have been so unsatisfactory that it led us to inquire of you relative to the furnishing of regular chilled cast iron wheels for this purpose." Chilled iron wheels were furnished and have served with satisfaction for three years. This indicates that for heavy concentrated loads, chilled iron has superior qualities, and that the only limit to car capacity is the ability of the rail to carry the load.

Heretofore a good many crane builders have used the standard M.C.B flange on wheels for crane service. This certainly is not correct, for in railroad service the thickness of flange is limited on account of crossings, switches, guard rails, etc., while in crane service, where the load carried by the wheel and the resulting flange pressure is several times greater than encountered in railroad service, there is unlimited space for designing flanges in proportion to the work which they must perform. Furthermore, for heavy cranes where the expense of changing wheels is large, and in case of renewals keeps the crane idle, an ample factor of safety should be used. This is also essential on wheels having two flanges, when the rail is out of level, giving excess work on one wheel, or the track is out of alignment, which changes the track gage, and one flange receives considerably more stress than calculated.



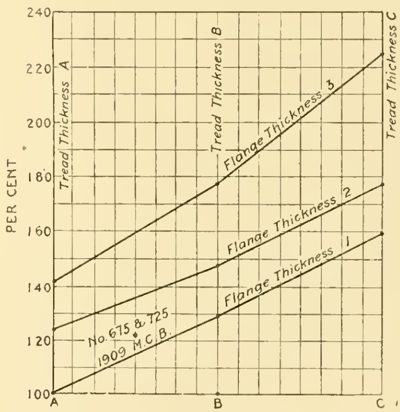




Fig. 3 Relative Strengths of Flanges for Various Thicknesses

*Standard Design for Crane Wheels.* Various designs of 12-in. to 36-in. double flange wheels were made, giving the maximum safe vertical load and the maximum safe flange pressure for each design. Full details of each wheel are shown in the paper.

The maximum vertical load given does not exceed the maximum stress that should be applied on the various steel rails shown in connection with the wheels.

In analyzing the metals available for the manufacture of wheels for crane service, the definite conclusion is reached that chilled iron has more desirable properties for heavy wheel service than any other known metal for the following reasons:

*a* Sufficient bearing strength to sustain the heaviest load imposed.

*b* Chilled iron does not crystallize and is free from structural defects.

*c* Has high resistance to abrasion and distortion under heavy pressures on the small area of contact between tread and rail.

*d* The chilled iron tread, on account of the absence of ductility, and coupled with the slow wearing qualities, retains the rotundity of the wheel to a larger extent than can be obtained with any other metal.

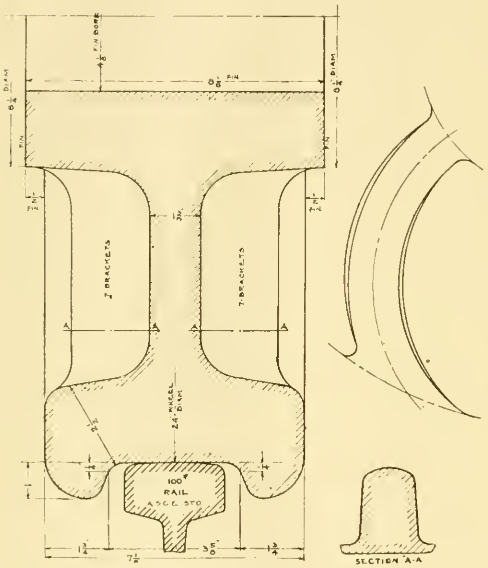



Fig. 4 24 In. 640 Lb. Double Flange Chilled Iron Crane Wheel, Single-Plate Type

*e* Flanges have high wearing qualities and when designed properly have sufficient strength to withstand all side thrusts imposed.

*f* Flanges of chilled iron produce far less abrasion on steel rail than if made of steel.

For consistent design there should be a fixed relation between flange thickness and throat thickness. Stated as a proportion, flange thickness is to throat thickness as two is to three. Stating this relation in another way—the addition of $\frac{1}{2}$ in. of metal to the flange is equivalent to adding $\frac{3}{4}$ in. of metal to the throat.

With wheels of different diameter, the flange strength varies approximately as their diameters, other conditions remaining the same. The addition of $\frac{1}{2}$ in. of metal to the flange of a wheel or $\frac{3}{4}$ in. to the throat of a wheel raises its strength to the 1.028th power.

In general the results obtained demonstrated that it was possible to design wheel flanges of chilled iron with absolute certainty that they would safely carry loads far in excess of the greatest used in present day practice.

That the limit of the bearing strength of the wheel itself is far in excess of anything that has yet been built was shown by tests made on 12-in. and 16-in. single plate wheels from which the flanges had been broken. Loads of 300,000 lb. were applied on the tops of these wheels without an appreciable deflection or flattening of the surface of the tread. This load was carried entirely by the plate and brackets of the wheel without any support from the flanges.

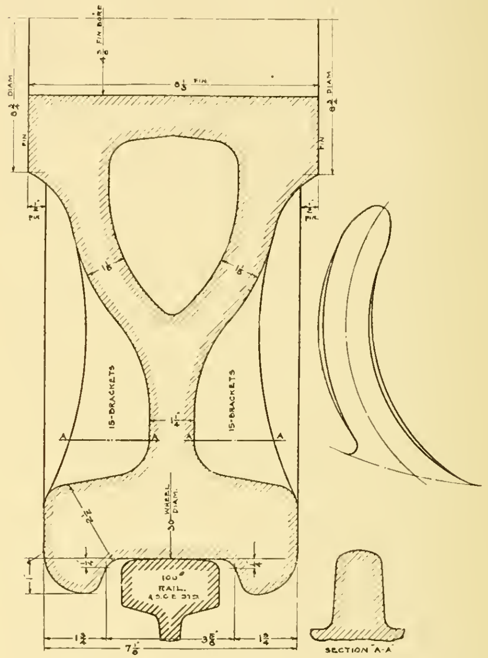



Fig. 5 30 In. 875 Lb. Double Flange Chilled Iron Crane Wheel, Double-Plate Type

Table 2 gives the safe strength of crane wheel flanges, using a factor of safety of five.

Fig. 3 shows, on the basis of the tests, the relative increase in strength of flanges for various thicknesses of flanges and tread sections. The inner lines are the contour of the 625 lb. M.C.B. flange and tread. Lines 2 and 3 are $\frac{1}{4}$ in. and $\frac{1}{2}$ in. increase in flange thickness, and lines *B* and *C* are $\frac{1}{2}$ in. and 1 in. increase in thickness of tread.

TABLE 2 SAFE STRENGTH OF CRANE WHEEL FLANGES AT A FACTOR OF SAFETY OF FIVE

| Diameter Inches | Flange Inches | Throat Inches | Rail, Lb. | Strength |
|---|---|---|---|---|
| 12 | 1 | $1\frac{1}{4}$ | 40 | 3,000 |
| | $1\frac{1}{4}$ | $1\frac{1}{2}$ | 50 | 5,000 |
| | $1\frac{1}{2}$ | 2 | 60 | 8,000 |
| 20 | 1 | $1\frac{1}{2}$ | 50 | 8,000 |
| | $1\frac{1}{4}$ | $1\frac{7}{8}$ | 60 | 11,000 |
| | $1\frac{1}{2}$ | $2\frac{1}{4}$ | 80 | 15,000 |
| 24 | $1\frac{1}{4}$ | $1\frac{3}{4}$ | 60 | 12,000 |
| | $1\frac{1}{2}$ | $2\frac{1}{8}$ | 80 | 18,000 |
| | $1\frac{3}{4}$ | $2\frac{1}{2}$ | 100 | 25,000 |
| 30 | $1\frac{1}{4}$ | $1\frac{3}{4}$ | 60 | 16,000 |
| | $1\frac{1}{2}$ | 2 | 80 | 22,000 |
| | $1\frac{3}{4}$ | $2\frac{1}{2}$ | 100 | 32,000 |
| | 2 | 3 | 100 | 47,000 |
| | $2\frac{1}{4}$ | $3\frac{1}{2}$ | 150 | 69,000 |
| 36 | $1\frac{1}{4}$ | $1\frac{3}{4}$ | 60 | 20,000 |
| | $1\frac{1}{2}$ | 2 | 80 | 26,000 |
| | $1\frac{3}{4}$ | $2\frac{1}{2}$ | 100 | 38,000 |
| | 2 | 3 | 100 | 56,000 |
| | $2\frac{1}{4}$ | $3\frac{1}{2}$ | 150 | 86,000 |

## DISCUSSION

Arthur L. Williston in commenting on the method described of finding the power required for locomotion by drawing a load up an inclined plane, called attention to the question of the friction of rolling between a smooth ground wheel and a smooth rail. The author had calculated this on the theory of the wheel running uphill. If the material were like lead, which is absolutely inelastic, that would be a correct way of calculating, in making the successive depressions in the rail as the wheel moves forward. With an elastic material like chilled iron, the condition is somewhat different. There is another force behind the wheel tending to push the wheel forward as the material tends to return to its natural condition. With a material like chilled iron running on an open hearth steel rail, from one-half to two-thirds of the work done in compressing the rails is returned by the elasticity of the materials.

W. A. Bennett[1] who presented the paper in the absence of the author said in reply that the chilled iron used is so hard that it has no ductility whatever; while it is not claimed that the theory of a body rolling up an inclined plane is absolutely correct, it gives a result within working limits.

W. L. Stork[2] in a written discussion accompanied by lantern slides showing microphotographs of the structure of chilled iron car wheels said that chemical analysis and condition of casting are equally, if not more, important in the standardization of crane wheels than standardization of design. The design can have no positive influence upon the quality of wheel if the condition and composition of the iron put into the wheel are not studied.

The chemical analysis of the metal and length of time in service of the wheels are given in Table 3.

The microphotographs showed the structure of four different wheels two of which gave excellent service and two lasted only a few months. They showed that there is a difference in structure in each wheel in passing from the chilled sections to the softer sections. Those of the good wheels show the metal hard, strong and dense. The metal of the other two wheels has a different structure. The chilling action also in the two good wheels was more severe and to a greater depth. With respect to the chemical analysis shown in the table, it is to be noted that the manganese, phosphorous and sulphur contents are the same for all wheels.

The higher the carbon content the greater the tendency for a graphitic structure; also the higher the carbon content the less is the change of chilling the casting. For high carbon contents the cooling and freezing cannot be rapid enough to retain all of the carbon in the combined form. Does not the chemical analysis and composition justify the metallography as shown in the photomicrographs? Are not the increase in graphite, the coarser structures and the decrease in cementite justified by the chemical composition?

TABLE 3. COMPOSITION OF WHEELS AND TIME IN ACTUAL USE

All Wheels Removed December 1 1911

| No. | Total Carbon | Si. | Mn. | P. | S. | Months in use |
|---|---|---|---|---|---|---|
| 2 | 3 00 | 0 65 | 0.40 | 0.440 | 0.137 | 36 |
| 22 | 3.22 | 0 45 | 0.53 | 0.296 | 0.124 | 8 |
| 13 | 2 60 | 0.52 | 0.51 | 0.390 | 0.140 | 118 |
| 18 | 2.62 | 0.50 | 0.53 | 0.300 | 0.153 | 111 |

Augustus Smith, in a written discussion, stated that, though the author's paper is not always convincing, the tests on the strength of flanges is valuable, and the suggestion that crane wheels should be designed according to the strength of the flange seems to be a very logical method. Nevertheless the method of designing the wheel outlined can be followed for any agreed upon ratio of horizontal flange stress to vertical wheel load.

No experiments were made on tractive force. The tractive force required for wheels of different diameters is derived by the author by a mathematical analysis which neglects the elastic properties of the rail and wheel in regaining their respective contours after the load is relieved or passes along, which shifting of the load to successive portions of the rail and wheel even aids in restoring the depressed contour. In the writers opinion, the results given are incorrect.

A line of investigation is suggested which would be a more accurate method of testing rail and wheel resistance to vertical loads; tests in which the tractive force required to roll wheels on rails under different loadings and different diameters of wheels is measured directly. Tractive force should vary with the load and be practically independent of the diameter of the wheel, after correction for journal friction, as long as the rail and wheel are perfectly smooth and the load does not exceed the elastic limit of either rail or wheel. If such tests were made with a glass-like unyielding wheel, the results would indicate the elastic limit of the bearing power of the rail. Another series of tests on a special rail of glassy hardness would indicate the elastic limit of the bearing power of different wheels made of softer material than the test rail.

[1] Griffin Wheel Co., Chicago.

[2] 212 Hancock Ave., Jersey City, N. J.

# THE MECHANICAL ELIMINATION OF SEAMS IN STEEL PRODUCTS, NOTABLY STEEL RAILS

BY ROBERT W. HUNT, CHICAGO, ILL.

Member of the Society

Increased weight of rolling stock and speed of traffic have led to increase in size of rail sections, requiring changes in the detail of rail manufacture. Under these conditions it is not surprising that new and unexpected physical weakness should develop in the heavier rails. One of the chief troubles has been failures through

Fig. 1 Face of an Ingot after Heating with the Adhering Scale Removed

crescent-shaped pieces breaking out of the rail flanges, followed by at least one, and in many cases several, ruptures across the whole section of the rail. Investigation showed that in practically every instance of such failure there was a more or less pronounced seam running longitudinally in the bottom of the rail near its center. This seam occurs at the top of the curve of the crescent-shaped break and is undoubtedly the point at which the fracture starts.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to nonmembers.

As a result of an investigation of the subject, T. H. Mathias, assistant general superintendent of the Lackawanna Steel Company, determined that the most certain way of getting rid of seams was to remove that portion of the metal which contained them. He reasoned that the primary causes of seams existed in the ingots and probably were incident to the casting of the ingots. The surfaces of ingots display disk-like apertures, due to entrapped air, which in rolling could easily be elongated into dangerous seams. It was demonstrated, also, that the surfaces of the ingots are decarburized to the extent of eight to ten points carbon and to a depth of 5/16 in., which must be detrimental to the finished product.

The removal of the surface metal is effected by a hot sawing, or milling operation during the process of rolling. The ingot is first reduced to a point where the product is 75 per cent finished, in the form of a partially shaped bar 60 ft. long, when it is entered between two pinch rolls with the flange side up and forced between two milling saws. A second set of rolls pulls on the bar and aids in holding it in line for the milling operation, for which purpose milling saws 5 ft. in diameter are used. Metal

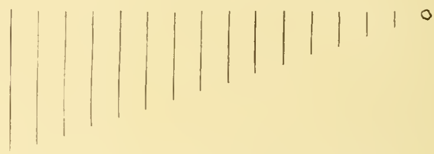


Fig. 2 Effect of Practically Round Imperfections when Elongated by 15 Passes in the Rolling Mill

is removed from the top and bottom of the bar, the main object being to eliminate the seams from the central portion of the bottom of the rail which has been the starting point of the moon-shaped failures, and to remove them from the top or bearing surface of the head of the rail.

In Fig. 1 is reproduced a photograph showing the actual size of a section of the face of an ingot as it appears after heating with the adhering scale removed. This view gives an illustration of how serious the disk-like apertures in the surface may be. As the section of the ingot is reduced and elongated in the rolling process, the apertures will be stretched longitudinally and formed into seams. Fig. 2 shows what would occur in that way to any practically round imperfections of the size indicated when elongated by 15 passes in the rolling mill. If so small an imperfection would give such a result, the seams resulting from larger ones would be proportionately greater and, therefore, more serious, both in length and depth.

In the operation of rolling, the ingot is reduced in the blooming rolls to an 8-in. by 8-in. cross-sec-

tion and after cropping the ends the bloom is further reduced in the roughing or shaping stand of rolls by five passes. A bar which will make four 33-ft. rails is at this point in the rolling operation about 60 ft. in length; therefore, the area of metal to be cut off or removed in the milling machine is approximately ⅛ in. deep, 7 in. wide and 60 ft. long. It is driven through the pinch rolls at a rate of 60 ft. in 30 seconds. The pinch rolls have a draft of about ⅜ in. and thus force the bar between the two milling saws, which are so arranged in the housing that they may be raised or lowered as desired. There is from $^1/_{32}$ to $^3/_{64}$ in. of metal milled from the head and base of the bar, the front end of which, immediately on passing from between the tools, is caught by a second set of pinch rolls which have a draft of about 1/16 in. These pinch rolls force the bar between the tools, pull it from between them, and also hold it in practically perfect line for the milling operation. The milling apparatus is driven electrically and requires about 600 h.p. for its operation.

Fig. 3 shows an etched cross-section of the piece preparatory to its entering the milling machine, and on it is clearly shown the enveloping layer of lower

Fig. 3 Cross-Section of Bar preparatory to entering Milling Machine

carbon steel. Fig. 4 presents the shape of the bar after it leaves the milling machine preparatory to further reduction in the regular rail rolls.

Fig. 5 shows the milling operation in process. As the milled dust or particles of steel are thrown out, they are hit by water under pressure which forces them into a chute which discharges them below and also prevents the material from adhering together. Fig. 6 shows one of the milling tools. It is 5 ft. in diameter with an 8 in. width of face and revolves at a peripheral speed of 2500 ft. per minute, thus causing an engagement of about 400,000 teeth per minute on the hot rail bar. The teeth are 0.80 carbon steel, and it has been demonstrated that they will mill at least 30,000 tons of material without requiring dressing. The one shown had milled about 15,000 tons.

Fig. 7 shows a piece of a rail broken under the drop press in which is plainly seen a pronounced seam in the flange directly under the center of its base, and is an illustration of a dangerous rail.

To illustrate the appearance of many ordinary steel rails of commerce when etched the author shows a collection of photographs of heads and flanges of rails of several different makers, including specimens

Fig. 4 Appearance of Bar after it Leaves the Milling Machine

from the Lackawanna Steel Company which have been milled by the Mathias process. Four views are reproduced herewith in Figs. 8 and 9 which are characteristic and representative of those given in the paper.

## DISCUSSION

H. C. Hibbard felt that the paper might be considered as curing a thing which ought not to be present at all. More of the seams are the result of rubbing, but undoubtedly, at least some of them have started from those surface skin holes which really ought not to be there in good steel. The speaker stated that he is still old-fashioned enough to agree with Captain Hunt, who said once that he believed the way to make good steel, was to make good steel. Formerly, good steel used to be made by proper furnace management, proper care of the gases and proper care of the impurities; and ingots were made such that rails rolled from them were actually perfect and showed no seams. Split, there was nothing to them but clear, sound, solid steel from one end to the other, and from top to bottom, so that they did not require to be milled to be free from seams. None of the rail ingots which represent current practice are sound. They all have pipes and a number of them have blow-holes. The speaker realizes the difficulties which rail mills have to meet owing to the plants which they have, to produce solid ingots, but at the same time, he believes that until that is done and until the production starts with the solid, sound ingot, it will be impossible to get a sound, solid rail.

Properly made steel should have a full liberty to pipe and the pipe should not be reduced or eliminated by holes in the other parts of the ingot. In an ingot cast without any spe-

cial precautions, the only hole that should be there should be the pipe and nothing but the pipe. There are two well tested means of getting rid of the pipe and of securing a sound ingot. One is by lateral pressure, and the other by keeping the top of the ingot hot. A rail ingot will probably keep melted in the interior from $1\frac{1}{4}$ to $1\frac{1}{2}$ hr. according to its size, after it has been cast, and whatever means is applied to prevent the pipe, it should probably start within fifteen minutes after the ingot is cast and should be continued until the metal is all solidified. This being properly done, there will result a good, sound ingot, and such an ingot properly rolled will give a rail without seams.

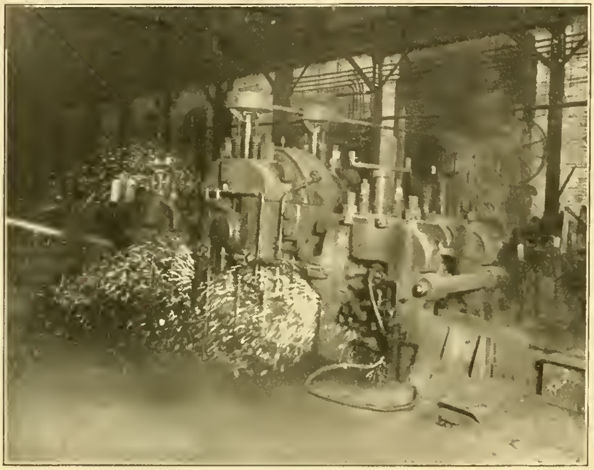


Fig. 5 Hot Sawing or Milling Machine in Operation

J. D. Howard, in a written discussion, pointed out that the report of the Committee on Rails and Equipment of the National Association of Railway Commissioners, presented at its recent convention held in Washington, D. C., in dealing with the subject of train accidents, furnished statistics from which it appears that the average daily losses due to derailments alone, for a term of 10 years, were at the rate of 1.04 persons killed, 14.4 persons injured, and a property loss of $15,900 per day. The total figures were 3,727 killed, 52,047 injured and property loss of $57,192,396.

An amelioration of such conditions is demanded and it is believed that milling the running surfaces of the heads and the lower surfaces of the bases of steel rails will remove certain recognized defects, and thereby tend to lessen the number of rail failures and the casualties incident thereto. It is understood that no claim is made for other than surface defects. The writer had witnessed the process of milling the bars and Mr. Mathias, who made very modest claims for it, expects that milled rails now in service will within a short time demonstrate the efficacy of the method.

The presence of streaked metal in rails, including both interior and exterior streaks, and low carbon surface metal, have occasioned comments in reports upon tests of steel rails. Such a soft metal surface when located over a hard steel core and exposed to wheel pressures at the running surface of the head, exerts an unfavorable influence, particularly when interior seaminess is present. It augments the wedging and splitting tendency of the wheel loads. Still earlier, Tests of Metals, 1909, showed a difference of 28 points in carbon between the center and the sides of the head of a 75 lb. rail.

Such occurrences are common and their frequency constitutes a sufficient basis for the claim advanced by Mr. Mathias that one of the features of his process consists of the removal of partially decarburized metal at the surface. There is less anxiety on account of the presence of decarburized surface metal at the base than at the head of the rail. Soft steel may even display the functions of a deterrent against the detrimental influence of seaminess in such places. Certain defects are negligible in soft steels which are serious in hard steels, such as slight serrations and indentations.

Streaky conditions in steel doubtless constitute serious problems for the steel maker. Such streaks are the cause of many rail failures, and they should be eliminated if it is feasible to do so. They tend to cause split heads and base fractures. The removal of such seams is a metallurgical question, in respect to which the steel makers do not offer great encouragement. Still. the case may be more hopeful than some statements would lead one to infer. Present information indicates that a more general state of interior seaminess exists in "A" rails over those of other parts of the ingot.

Referring to the investigation of rails conducted by the Commission, the metal of the heads and bases of a number of rails have been planed off to different depths, and a streaked state disclosed at each stage. Starting at the ingot, there is obviously no reason for expecting any different metal on the side which chances to become the head of the rail

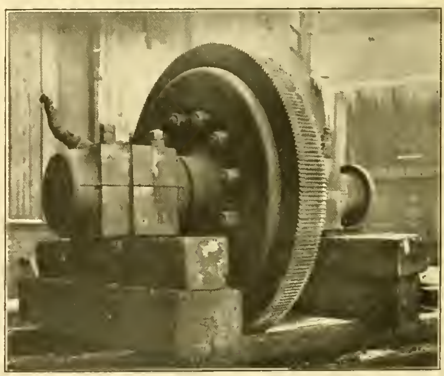


Fig. 6 A View of one of the Milling Tools

over that which happens to be rolled into the base. Interior streaks in the metal of the head should have their counterpart in the metal of the base.

The examination of the metal in a 100 lb. rail of recent manufacture, an "A" rail, showed the presence of 22 seams in the metal of the head, ranging in length from $\frac{1}{2}$ in. to $5\frac{1}{2}$ in., and at various depths up to $\frac{3}{4}$ in. Some were at the surface, but generally they were most prevalent at depths of $\frac{1}{8}$ in. to $\frac{3}{8}$ in. below the running surface. Those of the base were found at depths up to $\frac{9}{16}$ in. measured from the lower surface, lengths from $\frac{1}{2}$ in. to $7\frac{1}{2}$ in., and in from the edge of the flange 1 in. to $2\frac{3}{4}$ in. Twenty-three of these base seams were disclosed in this rail. Other rails from other heats and other parts of the ingot were free from interior streaks, so far as disclosed by the examination.

M. H. Wickhorst[1] expressed his admiration of the bravery of Mr. Mathias in getting up a milling machine that will mill a hot bar 60 feet long and do it while the bar is going through the rollers. He believes, however, that the cause of the seams in the rail is somewhat different from what Captain Hunt stated it to be. The deep seams in the rail flaws which extend anywhere from 0.08 to 0.12, or possibly 0.15 of an inch deep from the surface, seem rather to start from cracks in the ingot. If the scale is removed so that the surface can be really seen, it becomes apparent that most ingots are more or less cracked. When the ingot is rolled, the seams tend to crack open, and the amount depends upon the draft in the rolling. With a large draft, this crack will open wide and there will be in the surface of the bloom a sort of a double "V"-shaped affair. This zigzag shaped crack opens up in the first pass, and in the next passes, the crack will modify into a double "V"-shaped flaw, one inside the other. Further rolling simply presses them together so that at the stage of the bloom 8 to 10 in. sq., there will be a flaw which looks like a "Y," the two sides having come together and some of the "V" flaw still remaining. Still further rolling will simply extend the "Y" flaws in the bloom, so that when they come to a rail, or a small billet, there will be a very much elongated "Y," or generally a series of them together.

An interesting fact is that it seems that these flaws occur mostly on what are known as the two open sides of the ingot as it first enters the rolls. On the top and bottom sides, where actual compression is applied, the ingot probably tends to heal up. In this way, it may be possible to manage so that these seams will occur mostly in the thread, or the bottom, or the base of the rail, and the thought has occurred further that this can be made use of practically. Apparently seams that occur in the web, or top of the head, do not result in rail fracture, while those which occur in the base near the center under the web, do result in rail fractures, and as nearly as the speaker could determine, about 40 per cent of the rail failures in this country have on the average their origin in these deep seams at the base and particularly near the center.

P. H. Dudley[2] in a written discussion called attention to the fact that the adoption of basic open hearth steel for rails had reduced the breakages and failures to a marked extent. The checking of the basic open hearth ingots in blooming is not nearly so frequent as in Bessemer ingots, and half-moon or crescent shaped brakes have been reduced in the same sections of rails by nearly 50 per cent. Over three decades ago some railroad companies have designed stiffer sections with a better distribution of the metal so as to carry heavier wheel loads with lower unit stress. Service tests in the track demonstrated that with the higher standards of track secured by the stiffer and heavier sections, and under an increase of wheel loads and higher speed, mechanical abrasion of the cross ties under the rail, the disturbance of ballast and roadbed, were less than under the early light rails and lighter wheel loads, and there was also a reduction of rails in service for the tons carried. Of course the rail sections of three decades ago could not be expected to be adequate to meet the present heavier wheel loads, and three to four times the volume of traffic. Weight is but one

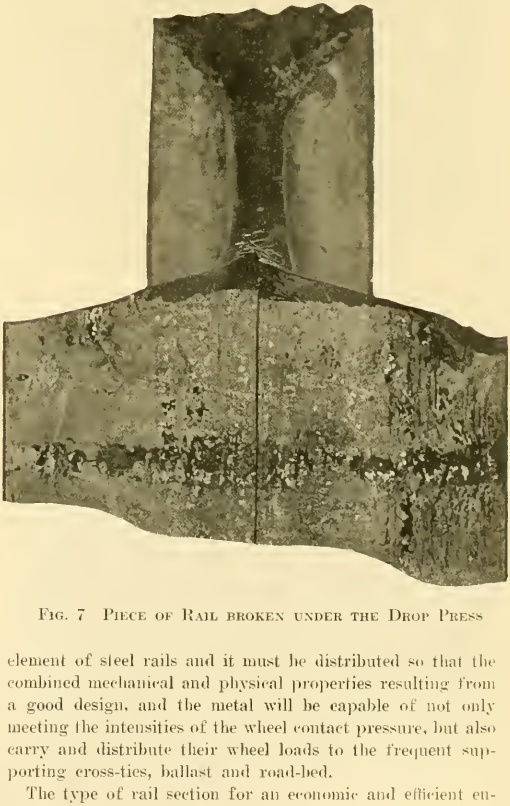


Fig. 7 Piece of Rail broken under the Drop Press

element of steel rails and it must be distributed so that the combined mechanical and physical properties resulting from a good design, and the metal will be capable of not only meeting the intensities of the wheel contact pressure, but also carry and distribute their wheel loads to the frequent supporting cross-ties, ballast and road-bed.

The type of rail section for an economic and efficient engineering structure, must have the metal distributed in sufficient width of head to maintain large wheel contacts and moderate intensity of pressure on the bearing surface of the head. It is a misconception of the relations of the wheel contacts on the bearing surface of the rail heads to assume that as the wheel loads have increased the areas of the contacts between each have been reduced by the recent coning and shape of the wheel tread contours. The Pennsylvania Railroad Company has made their new 125 lb. rail for trial with a 3-in. wide head, while the New York Central and the

[1] Eng. of Tests, Rail Committee, Am. Ry. Engrg. Assoc., Chicago.
[2] Consulting Eng., Grand Central Terminal, New York.

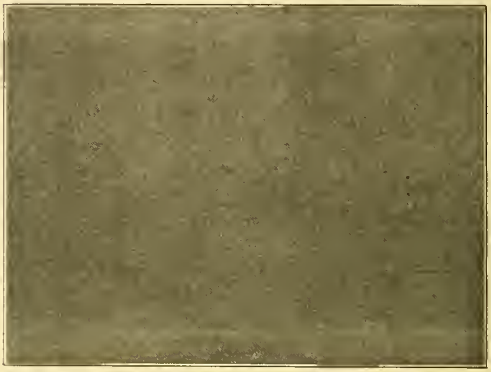
Boston & Albany Railroad Companies have each used a rail head 3 in. wide for twenty-two and twenty-three years respectively.

Consumers of rails hope that soon there will be installed less injurious methods of straightening the rails of stiffer sections than those now in use. Deep ragging of the blooming rolls must also be considered, for it has been found that where rails are rolled with lighter passes and diagonal roughing, the cracks in the bases of the rails are less than where the drafts in the blooming passes are heavy and their ragging deep.

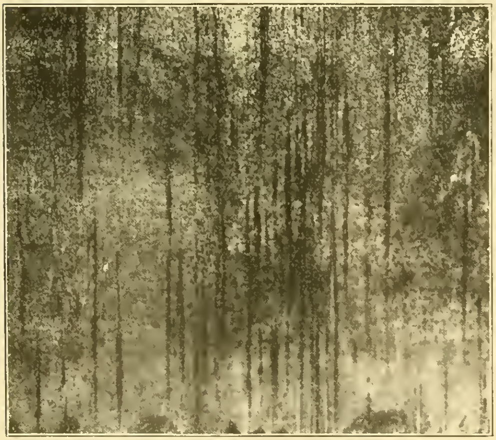
The writer congratulated Mr. Mathias on the introduction of his " hot miller " as a step in advance in rail manufacture, which is also a proof of the manufacturers' efforts to eliminate the slight defects in their products, so that they will meet all of the exacting conditions of present service.

The Author in conclusion said that he fully agreed in regard to the necessity for making sound ingots. He had not departed from his " old-fasioned " position in regard to that; but as long as sound ingots are not generally made, it is a good thing to try as far as possible to ameliorate their bad effects. This process will not remove deep seams. It will simply eliminate a certain class of seams which occur in practice however careful the manufacturer may be and it will remove the decarburized skin. This process removes the superficial seams after which, if the inspector still finds defects of this character he knows he has a deep seam and ought to condemn the rail.

Top Surface



Top Surface



Bottom Surface

Fig. 8 Untreated Rail

Bottom Surface

Fig. 9 Milled Rail

# CEMENT SESSION

*FOLLOWING the custom of previous meetings, the Cement Session was an informal gathering of those interested in cement manufacturing held in the rooms of the Society on the eleventh floor. There were about twenty in attendance. The author, Mr. Porter, illustrated his paper during its presentation with stereoptican views. After the presentation of the paper, the author answered a number of questions and an informal discussion was participated in. There was no stenographer present, however, and the discussion was not made a matter of record.*

## ELECTRIC DRIVE FOR ECONOMIC OPERATION AND DEVELOPMENT OF CEMENT MILLS

BY J. BENTON PORTER, PHILADELPHIA, PA.

Member of the Society

Electricity was first used only for lighting in cement plants; next it was employed to drive machinery located in inconvenient places; then it was used for driving the auxiliary apparatus, and it later enabled the manufacturer to locate this auxiliary apparatus more conveniently; next it provided more flexibility and greater output from the kilns; and finally, electrically is being universally adopted for the entire plant. The last five plants put into operation have installed individual motor drive and five other plants have changed to the electrical drive during the last two years.

A review of the reasons for this growth in the application of electricity to the manufacture of cement will be interesting:

*a* It enables the manufacturer to purchase power from central stations, thereby eliminating one of the greatest cost fluctuations from the cost of manufacturing cement.

*b* It gives a greater flexibility, permitting economical operation under varying conditions of output.

*c* It keeps the driven machine nearer to a predetermined speed, thereby increasing the output and maintaining the quality. As an example, one plant increased its output over 6 per cent by improving its speed regulation.

*d* The first cost and maintenance are no longer a nightmare to the management, as years of practical experience have shown that the advantages obtained have justified the cost and that the maintenance compared very favorably with the balance of the equipment.

*e* The electric drive has largely eliminated the human element, necessary in making reports, and automatically keeps a record of the power consumed in a plant with an accuracy that cannot be attempted with the mechanical drive.

Only a few managers have realized, or utilized one of the most contributory factors, namely, the various records that electricity can give. This paper is presented in order to call attention more strongly to the value of this salient attribute of electricity, by showing some of the records already compiled, and suggesting some of its future potentialities.

If it were possible to save one cent for every barrel of cement manufactured, how much money would a manager be justified in spending to obtain such an improvement? In a plant turning out 1000 barrels a day, the saving would amount to about $3600.00 a year, and such a plant would be justified in borrowing about $20,000.00 in order to accomplish such a saving. Similarly, a 5000 barrel plant could afford to expend about $100.000.00.

The manufacturer has already inaugurated different systems to find out where the weak points are in his process, but he has been badly handicapped, for he has had to base his records on reports that are not wholly accurate. The assumption that all his mills are running at their maximum capacity as long as they are in operation has to a very great extent been the ground plan; but accurate tests taken on any one machine show that it is almost impossible to keep a mill at a constant load and output, even when meters are installed and the feed regulated to keep the meter needle at a predetermined point.

The advantage of eliminating variables from the manufacturing of cement is apparent when we realize the variations in coal and the variables also shown in the manufacture of steam, which varies in evaporation from 4 lb. of water up to 10 lb. for each lb. of coal. It has also been pointed out clearly that in the production of power from this steam where the consumption may vary from 30 lb. down to 12½ lb. and even lower; and even condensers vary depending on the volume and temperature of the water. These variables, as far as records have shown in cement manufacture, are by far the greatest.

The standard forms of contracts for the sale of power supplied by central stations call attention very strongly to the fact that the customer can purchase power more advantageously if his load factor is kept high. This means that if the daily readings of power required for the operations of the plant were plotted into a curve, this curve should come as near as possible to a *straight line*, since this condition would result in

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Abstract of paper presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

many intrinsic advantages both to the customer and producer of power.

Fig. 1 shows readings taken of the power consumption in an electrically driven plant. The line *B* gives the average of these readings. The line *C* is determined by taking the total kilowatts consumed during the entire 24 hours and dividing this total by 24; and

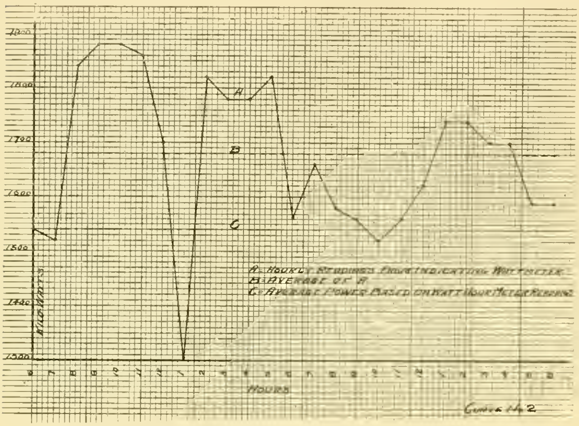


Fig. 1 Power Readings from Electrically-driven Plant

is, therefore, the only accurate record of the power consumed.

It is impossible to obtain a line like *C* from a mechanically driven plant and the difference between the lines *B* and *C* shows the possibility of error, even in the best records of the mechanically driven plant. In the latter, the basis for figuring the cost of power for the entire year has been periodical readings of indicator cards, and these have also been used to determine the amount of power it took in that particular plant to produce a barrel of cement.

The above calculations are based on the assumption that the power required to produce a barrel of cement is always constant, but this is absolutely incorrect. Fig. 2 shows the kilowatts consumed to produce a barrel of cement over a period of 31 consecutive days, and from this curve it is almost impossible to find two consecutive days where the ratio is constant. Thus it is not fair to compare the mechanical drive with the electric drive either in the cost of power or in the amount of power required to produce a barrel of cement.

Continuous operation has been and always must be the watchword for the cement manager. In addition to this he has always striven to run his machines at their maximum capacity. In other words, he has tried to keep his load constant and at the highest possible average, which, if illustrated by a curve, should show a *straight line*. From curves showing the power taken in different departments each day and over a period of an entire month, those that show the greatest variation from the average *straight line* are indicated, which are the departments that require the greatest study in order to bring them into the closest possible relation to the *straight line*.

By the installation of the individual motor drive, the separation of the various departments in the daily reports and the compilation of these records systematically arranged, the plant manager has a report which enables him to place his finger on any loose ends and even to anticipate where trouble may arise; to trace out an individual machine that is causing an over-demand of power, and after investigation to correct the trouble.

Records taken from tests of power taken in different departments will exhibit clearly an outline of the foundation of plans for improvement. The "Automatic Superintendent," which is to be used only as a base, enables the manager to make wonderful improvements, as it shows him where the improvements are most needed. No one can predict how great are the improvements that can be effected in the efficiency of cement manufacture. There is no general law that can be laid down for any particular class of mills, as the varied conditions of installation and the raw materials are so entirely different.


Fig. 2 Kilowatts per Barrel, Consecutive Run

# MISCELLANEOUS PAPERS

*THE Friday morning session of the Annual Meeting, December 4, was devoted to a number of papers upon miscellaneous subjects as follows: A Rate-Flow Meter, by H. C. Hayes; Laboratory for Testing and Investigating Liquid Flow Meters of Large Capacity, by W. S. Giele: A New Volume Regulator for Air Compressors, by Ragnar Wikander; Physical Laws of Methane Gas, by P. F. Walker; The Clinkering of Coal, by Lionel S. Marks; and Damages for Loss of Water Power, by F. W. Dean. The papers are here presented together with their discussions in abstract with the exception of that on The Clinkering of Coal, by L. S. Marks, which will appear in abstract form in the April issue.*

## A RATE-FLOW METER

BY H. C. HAYES,[1] SWARTHMORE, PA.

Non-Member

The velocity with which a fluid flows through a conduit can be determined by finding either its kinetic energy or its change in potential energy with respect to the direction of flow.

In the equation

$$H = \frac{V^2}{2g}$$

where $V$ is the velocity of the fluid and $g$ is the acceleration due to gravity.

The value of $H$ is determined experimentally as the height the fluid is raised by the impact pressure. The pitot tube operates in accordance with this formula, and an application of the formula leads to Thompson's formula

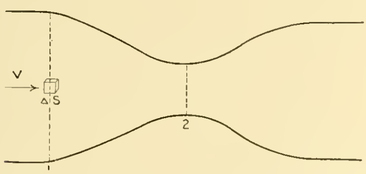


Fig. 1 Section of Conduit of Non-Uniform Cross-Sections

$$Q = K.H^{\frac{5}{2}} \text{ or } Q = K\sqrt{H^5}$$

where $Q$ is the quantity which flows in one second through a V-shaped weir, $K$ is a factor of proportionality, and $H$ is the height of the water level above the bottom of the notch.

The relation between the velocity of the moving fluid and the change of pressure with respect to the direction of flow is obtained through Newton's Law of Motion, mass times acceleration equals the accelerating force.

In Fig. 1 consider the small element of volume $ds^3$ of the moving fluid having the front and rear faces perpendicular to the direction of flow. Let $\rho$ be the density of the fluid supposed to be incompressible. Then from Newton's Law we have:

$$\rho \, . \, ds^3 . \, a = dp \, . \, ds^2$$

where $dp$ is the pressure difference at the front and rear faces. This simplifies to:

$$\rho a = \frac{dp}{ds}$$

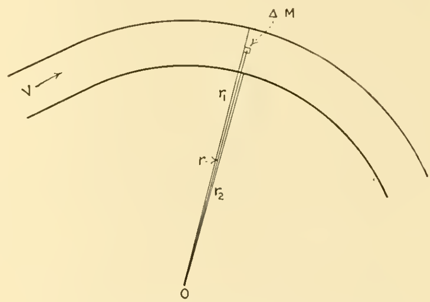


Fig. 2 Conduit Bent in Arc of a Circle

Putting for $a$ its equal $\frac{dV}{dt}$, and for $ds$ its equal $V \, . \, dt$, we get the following relation

$$V \, . \, dV = \frac{1}{\rho} dp$$

Integrating this equation between the points 1 and 2 gives

$$\frac{\rho}{2} (V^2_1 - V^2_2) = P_1 - P_2$$

which states that the gain in kinetic energy is equal to the loss of potential energy.

Calling $A_1$ and $A_2$ the cross-section of the conduit at the points 1 and 2 respectively, we get through the law of continuity the relation

$$A_1 V_1 = A_2 V_2$$

This enables us to express $V_2$ in terms of $V_1$ and the equation becomes

$$\frac{\rho}{2} \left( \frac{A^2_1}{A^2_2} V^2_1 - V^2_1 \right) = P_1 - P_2$$

By expressing the pressure difference in terms of head and the cross-sections in terms of diameter the equation simplifies to

[1] Prof. of Physics, Swarthmore College. The experiments were conducted at Harvard University, where Dr. Hayes was formerly connected with the Jefferson Physical Laboratory.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

$$H = \frac{V^2_1}{2g}\left(\frac{D^4_1}{D^4_2} - 1\right)$$

The venturi meter operates in accordance with this equation.

A trustworthy feedwater record is now looked upon as a necessity in all up-to-date steam plants, for it gives important information concerning the efficiency of the system. Such a record shows how many pounds of water are evaporated per pound of coal.

The meter described here was designed especially to give records showing such things as rate of evaporation of water per unit of coal, irregularities in boiler feed, leaks and slipping losses.

This meter operates through the relation which exists between the velocity of a moving fluid and the change of pressure in a direction perpendicular to the direction of flow. The pressure gradient in this direction is, of course, zero unless the flow lines are distorted. When these lines are made to describe the arc of a circle the relation is simple.

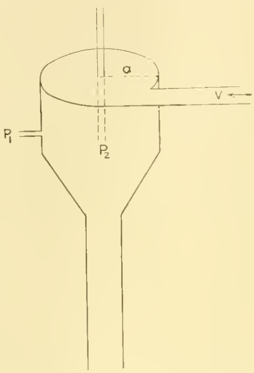


Fig. 3 Conduit so Shaped that a Vortex is Formed in the Moving Fluid

Suppose, in accordance with Fig. 2, the conduit is bent in a circular arc of outside radius $r_1$ and inside radius $r_2$. A difference in pressure will exist between points 1 and 2 due to the centrifugal force. A small mass $dM$ at a distance $r$ will give an increment of pressure $dP$ outward along the radius such that:

$$dP = \frac{dM\ .\ V^2}{g\ .\ r}$$

The difference in pressure at the points 1 and 2 is given by integrating this expression from $r_2$ to $r_1$,

$$P_1 - P_2 = \int_{r_2}^{r_1} \frac{dM\ .\ V^2}{gr}$$

If the fluid is incompressible,

$$dM = \rho\ .\ ds^2.\ dr$$

and if we neglect the effect of viscosity, as has been done in obtaining all the formulæ, $V$ will be independent of $r$ and our expression becomes:

$$P_1 - P_2 = \frac{\rho\ .\ ds^2.\ V^2}{g}\int_{r_2}^{r_1}\frac{dr}{r} = \frac{\rho\ .\ ds^2.\ V^2}{g}\log.\frac{r_1}{r_2}$$

and in order that $P_1$ and $P_2$ shall be the pressure per unit area, $ds$ must equal 1. Making this change and writing $P_1 - P_2$ in terms of head we get the relation

$$H = \frac{V^2}{g}\log\frac{r_1}{r_2} = KV^2$$

and some idea of the value of $K$ can be obtained by expanding $\log\frac{r_1}{r_2}$ in a series, which ultimately gives

$$\frac{D}{r} + \frac{1}{3}\left(\frac{D}{r}\right)^3 + \frac{1}{5}\left(\frac{D}{r}\right)^5$$

where $D$ = diameter of conduit and $r = \frac{1}{2}(r_1 + r_2)$.

If $\frac{D}{r}$ is less than 0.67 all but the first term of the series can be neglected and still leave the formula accurate to within 1 per cent. Giving $\frac{D}{r}$ this value we find that

$$K = 0.021$$

wherefore

$$H = 0.021\ V^2$$

A meter of this form works well for measuring large values of $V$, but is not sensitive enough for feedwater purposes. The factor of proportionality increases as $r_2$ is made smaller, but the higher terms can no longer be neglected, and when $r_2$ approaches zero the flow approaches more and more nearly to vortex conditions.

Suppose the conduit is so shaped that a vortex is formed, as shown in Fig. 3. The pressure difference between points 1 and 2 will approximate the value given by a circular vortex of the same cross-section and the value of the circulation corresponding to the velocity, $V$. The difference in pressure between the center and outside of a circular vortex of radius $a$ is:

$$P_1 - P_2 = \frac{\rho\ K^2\ a^2}{8\pi^2 a^4}$$

where $K$ is the value of the circulation and is here equal to $2\pi a V$. Substituting this value and expressing the pressure difference in terms of head we have:

$$H = 0.5\ V^2$$

This result is but a rough approximation for the stream lines are spirals instead of circles, but the formula suggests that a sensitive meter might be constructed along these lines. Such a meter should not be greatly affected by fluctuations in pressure such as are always produced by feedwater pumps, for the inertia of the vortical mass will serve to steady the gage readings much as the flywheel does the motions of an engine.

Distortion of the entering stream lines through faulty connections or elbows placed too near the meter

will affect the readings but little as these distortions will become straightened in the vortex before the pressure terminals are reached. Finally, the sensitiveness of the meter can be changed by moving the low-pressure vent along a radius of the vortex and as a result the meter could possibly be made to give correct results for any particular temperature by setting the low-pressure vent properly.

This will be possible if the percentage correction in $H$ caused by moving the low-pressure vent is independent of the flow; and if the correction so introduced is proportional to the distance the vent is moved, and the correction which is made necessary through change of temperature is proportional to the temperature change, then it follows that the meter can be made self-compensating by causing the low-pressure vent to be moved by an unequal expansion arrangement, providing the required motion is small.

Whether or not these conditions will be fulfilled can be predicted if the vortex is regarded as circular, for which it is shown that the percentage change in $H$ is independent of $K$ and therefore independent of $V$.

Calling **H** the change in $H$ caused by moving the low-pressure vent a distance $r$ from the center, we have for the relation between **H** and $r$

$$r^2 = \frac{8\pi^2 a^4}{K^2} \mathbf{H}$$

a parabolic and not a linear relation. Plotting this equation for different values of $V$, i.e., for different values of $K$, we have a family of parabolas, five of which are shown in Fig. 4. The change in $H$, caused by shifting the central vent a distance $\triangle r$, will be

$$\triangle H = \frac{d\mathbf{H}}{dr} \cdot \triangle r = \frac{K^2}{4\pi^2 a^4} \cdot r \cdot \triangle r$$

and if $r$ is large with respect to $\triangle r$ the percentage change in $r$ will be small and the change in $H$ will be nearly proportional to the change in $r$, $\frac{\triangle H}{\triangle r} = \frac{K^2 r}{4\pi^2 a^4}$, a constant practically.

The change in $r$ necessary to correct for temperature will probably be small, comparable to $r_1$ minus $r_2$ in the figure, and if the normal position of the low-pressure vent is a distance from the center $r_1$, then, as shown in the figure, the relation between $r$ and $H$ for values of $r$ between $r_1$ and $r_2$ is nearly linear. Under these conditions we may assume that the correction introduced by changing $r$ is proportional to the change.

It remains to consider whether the error caused by change of temperature is proportional to the temperature change. The error introduced by change of temperature arises from two sources: first, from the resulting change in the density of the liquid and the second, from the change in viscosity. These errors may or may not tend to neutralize one another depending on whether the meter is calibrated to give the flow in terms of weight or volume.

The calibration curve for the meter is

$$H = K V^a$$

and if $H$ is expressed as pressure the equation becomes

$$p = \rho H = \rho K V^a$$

Calling $p_c$ and $\rho_c$ the pressure and density respectively at the calibration temperature, and $p_t$ and $\rho_t$ the corresponding values at some higher temperature $t$, we have the two equations

$$p_c = \rho_c K V^a$$
$$p_t = \rho_t K V^a$$

and if $V$, supposed here to be in terms of volume, is the same in each equation we have for the percentage error caused by the change of temperature:

$$\frac{p_t - p_c}{p_c} = \frac{\rho_t - \rho_c}{\rho_c}$$

And if we assume a linear relation between the density and the temperature, which is very nearly true, the error will be proportional to the change in temperature.

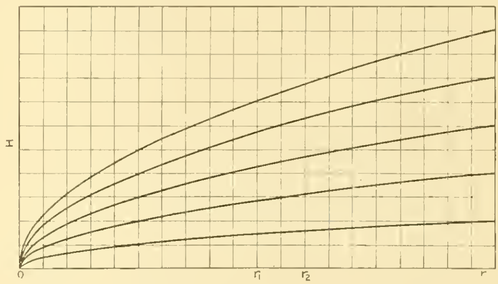

FIG. 4 FIVE CURVES OF THE FAMILY $H = K^2 . r^2/8\pi^2 a^4$

This error will be negative since $\rho_t$ is less than $\rho_c$, and must be corrected by moving the low-pressure vent toward the center.

If the meter is calibrated for flow in terms of weight we have for the relation between $V$ and $W$

$$W = k\rho V$$

where $k$ is a factor of proportionality and $W$ is the weight of flow per second. The calibration equation becomes

$$p = \rho K \left(\frac{W}{k\rho}\right)^a$$

and, as above, we have

$$p_c = \rho_c K \left(\frac{W}{k \rho_c}\right)^a = \frac{1}{\rho_c^{a-1}} \cdot \frac{K}{k^a} \cdot W^a$$

$$p_t = \frac{1}{\rho_t^{a-1}} \cdot \frac{K}{k^{a-1}} \cdot W^a$$

and the percentage error is

$$\frac{p_t - p_c}{p_c} = \frac{\rho_c^{a-1} - \rho_t^{a-1}}{\rho_t^{a-1}}$$

If $a$ has the value 2 as has been predicted, then the error here will also be about proportional to the temperature change, but the error is positive for $\rho_t$ is less than $\rho_c$, and the error must be compensated for by

moving the low-pressure vent from the center. In either case the error will be about 0.02 per cent per deg. fahr.

The error introduced by change of viscosity can be predicted as follows: It can be shown that $H$ is proportional to the kinetic energy of the vortical mass and we therefore have the relation

$$H = k\ (E - D)$$

where $E$ is the kinetic energy, this mass would have if the liquid were nonviscous and $D$ is the energy dissipated, changed to heat, as the water passes through the meter. The value of $D$ can be shown to be pro-

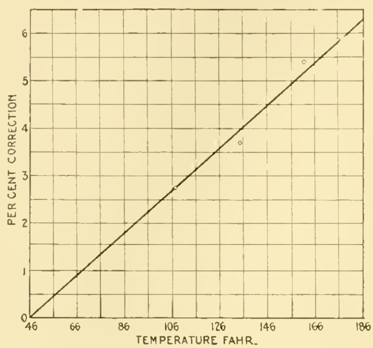


Fig. 5 Curve Indicating Error Due to Temperature Change

portional to $\mu$, the coefficient of viscosity of the liquid. The relation between $H$ and $\mu$ is therefore

$$H = A - B\mu$$

and $H$ varies inversely as $\mu$.

The relation between the coefficient of viscosity and the temperature is nearly linear if the temperature does not approach too near to freezing, so in case of feedwater we may assume the linear relation. The error introduced by change of viscosity will be positive and must be compensated for by moving the low-pressure vent away from the center of the vortex. This error will amount to about 0.026 per cent per deg. fahr.

It results that the errors introduced by change of temperature nearly cancel one another if the meter is calibrated to give the flow in terms of volume, becoming —0.02 per cent+0.026 per cent, or 0.006 per cent per deg. fahr.; but if the flow is given in terms of weight, as is usually desired in feedwater measurements, the errors will add giving a resulting error of 0.046 per cent per deg. fahr. These expectations have been very nearly met in the operation of two models of somewhat different form.

## EXPERIMENTAL RESULTS

Two models of the meter were constructed and tested in various ways.

This meter operates in accordance with the relation connecting the flow and the resulting difference in pressure between the surface and axis of a spiral vortex. The meter is fully as simple as the venturi or pitot forms and possesses several points of superiority. It consists of a cylindrical chamber terminating in a cone at one end and the other end capped, as shown in the accompanying diagram.

The fluid enters through a tangential inlet, thus giving a vortical motion to the contents of the chamber, and leaves through an axial outlet into which the cone terminates. The low-pressure tap is taken out through the center of the top cap and the high-pressure tap through the side of the chamber. It is to be noticed that the meter has no moveable parts and hence nothing to wear and get out of adjustment.

The calibration curve for this meter is much like that given by the venturi and pitot forms being

$$H = K \cdot V^{a}$$

where $a$ is a constant as is also $K$, and $V$ and $H$ are the velocity of flow and the meter head respectively. The value of $K$ for the vortex form is about 4 times that for the pitot forms and 3 times that for the venturi meter having diameter ratio of 2:1. The value

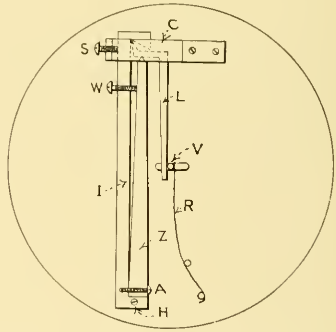


Fig. 6 Temperature Compensating Device

of the exponent, $a$, is 2.20, and for the venturi and pitot forms it is 2. This results in making the vortex meter sensitive and thus applicable to the measurement of low rates of flow such as is met with in feedwater conditions.

Four tests were made at different temperatures to determine the error for which the meter must be corrected. These results are given in Fig. 5. The meter was calibrated at temperature 46 deg. fahr. The percentage correction was determined in each case by dividing the actual flow, as given by weighing the discharge, into the difference between this and the value given by the meter. The curve has these values for the ordinates and temperature fahrenheit for abscissæ.

Here again we find a linear relation. The error introduced by changing temperature is proportional to the temperature change. The slope of the curve is 0.045 per cent. This is the percentage error introduced by changing the temperature 1 deg. fahr. Dividing this by the percentage variation caused by turning the thumbscrew once gives the number of turns required to correct the meter for a change of one degree temperature.

It results from this division that 0.0572 of a turn of the thumbscrew will correct for one degree change of temperature, and since the pitch of the thread is 0.025 in., the distance that the vent moves is 0.00143 in. This motion can easily be given by an unequal expansion arrangement and then the meter will give correct results at all temperatures. The design of this compensating device is shown in Fig. 6. The unequal expansion elements, *I* and *Z*, are made of invar steel and zinc respectively. The ratio of their coefficients of expansion is $\frac{8.7}{262}$. One end of the zinc element butts against a projection on the steel and is held in this position by means of the screw, *A*. Another screw *H*, fastens this end of the combination to the diaphragm. The movable arm *L*, passes across the free end of the zinc and pivots against an offset on the steel. The sensitiveness of the device can be varied by means of the set-screw *W*. The cap *C*, serves to hold the lever *L*, in position and also keeps the expansion elements pressed against the diaphragm. The expansion elements and lever can be rotated about the screw *H*, as a pivot by turning the set-screw *S*. This permits the adjusting of the lever *L*, against the vent-tube *V*. This tube is held firmly against the lever by the spring *R*. The whole expansion device is attached to the side of the diaphragm opposite to the vortex chamber, and since the diaphragm is made of brass which is a good heat conductor, the expansion elements take up the temperature of the water very quickly.

The meter, thus compensated, has been tested at various temperatures between 43 and 180 deg. fahr. and in no case was the error greater than 1.5 per cent, while the average error was below 1 per cent.

### THE RECORDING DEVICE

The calibration curve for any rate-flow meter, except perhaps one with movable parts, is of the form

$$H = K \cdot V^{\alpha}$$

where *H* is the meter head, *V* the velocity of flow, and K and $\alpha$ constants. The value of $\alpha$ must be about 2 while the value of K depends on the type and geometric form of the meter. This parabolic relation between *H* and *V* makes it difficult to measure the lower values of *V*, and if the value of *H* is measured with an ordinary manometer gage, the percentage error in the measurement of *V* increases rapidly as *V* decreases.

Thus far three schemes have been employed for overcoming this weakness. In all three the pen, or pointer if the instrument is not self-recording, is moved by the operation of a float placed in one arm of the mercury manometer. According to one scheme the float operates a parabolic cam which in turn gives to the pen a motion proportional to the rate of flow. In the Lee recorder a displacement of the float causes a cylinder to rotate. The calibration curve of the meter is cut about the cylinder in a spiral-shaped groove. Through a roller contact the pen is made to follow the groove as the cylinder rotates thus giving a deflection proportional to the rate of flow. The third scheme employs a float of variable cross-section. The displacement of the float is opposed by a force

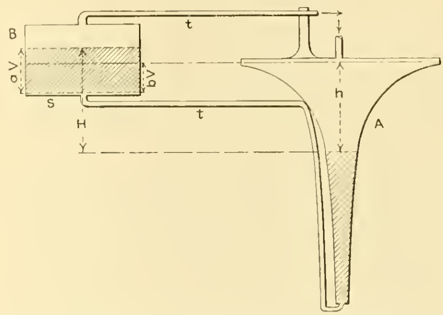


Fig. 7 Diagram showing Principle of Recording Device

which is proportional to the displacement, and the shape of the float is such that its displacement as the mercury level changes, is proportional to the rate of flow.

In all three types the motion of the float has to be transferred to the apparatus outside through a rod which passes through a packing-box. The friction at this point is considerable and prevents the float from taking its true position. This difficulty is partly overcome by making the float large, but this requires a great amount of mercury and increases the cost of the apparatus. In all the cam types the error caused by pen friction is much greater for low than for high velocities for the ratio of pen to float motion is greater at low velocities.

The recorder to be described, the principle of which is shown in Fig. 7, is free from these defects. The apparatus is simply a manometer gage with one arm movable and the other one of variable cross-section. The high-pressure terminal of the meter attaches to the bell-shaped tube *A*, and the low-pressure terminal to the top of the movable arm *B*. The bottom of the two arms, *A* and *B*, are connected through the small tube *t*. Both the connections to arm *B* are made through flexible steel tubing and thus allows the arm

$B$ to spring up and down. When the meter is in operation mercury is forced from $A$ to $B$ until the difference in level is equal to the meter head $H$, and if the shape of tube $A$ is such that the quantity of mercury forced into $B$ is proportional to the rate of flow through the meter, then the depression of the arm $B$, due to this weight will be proportional to $V$. This motion can easily be transferred to pen or pointer.

The form of tube $A$ depends, of course, on the shape of the calibration curve of the meter and can be found as follows. Let this calibration curve be

$$H = K \cdot V^{a} \qquad [1$$

and let $h$ be the depression of mercury in tube $A$ when a given velocity of flow $V$ is taking place through the meter. Then if the cross-section of $B$ is uniform and we assume that the weight of mercury forced into this arm is proportional to $V$, the depth of the mercury will also be proportional to $V$. Call this factor of proportionality $a$. At the same time the arm $B$ has been depressed a distance proportional to $V$. Call this factor of proportionality $b$. Then the meter head $H$ is related to these displacements as follows:

$$H = h + aV - bV = h + (a - b)\ V \qquad [2]$$

The quantity of water that has passed the meter during any interval of time will be accurately given by the area underneath that portion of the rate curve corresponding to the interval in question providing the velocity has not, during this interval, fallen below 0.216 ft. per sec.

The quantity of mercury required is comparatively small, being about 200 cu. cm. The restoring force for a small displacement of the pen is great because all the displaced mercury tends to restore equilibrium and not the portion displaced by a float. Moreover, the friction of movable parts is reduced to practically that of pen friction.

## DISCUSSION

F. ZUR NEDDEN referred to the loss of head caused by the meter. He thought that the dilatation of the lower part of the experimental meter, shown, was rather sudden and that if the venturi meter should be designed in the same way, with the dilatation as sudden as in this vortex chamber, probably the loss of head would be about the same as in the Hayes' meter. He suggested that the stretching out of the lower part and shaping it more toward the form of the diffusive part of the venturi meter, the result would be better.

Mr. Nedden pointed out that the author in his enumeration of devices for the recording of flow, had apparently overlooked one design which, is in a way, similar to his own. He referred to the design of the late Dr. Ansler of Schaffhausen in Switzerland which is known as a plano meter. This apparatus is very little known but one made by Dr. Ansler was tried out in Canada in connection with a venturi meter. It consists of two vessels which are connected by a U-shaped flexible tube, and filled with mercury, fixed to a weighing level. Mr. Nedden proceeded then to describe the device and he pointed out the features which render the recorder more sensitive as the zero rate of flow is approached, suggesting that the application of this principle might further intensify the accuracy of the vortex meter described by the author.

Mr. Nedden expressed doubt as to whether the Hayes' meter will in itself record accurately in the neighborhood of zero, as he had noted in checking the curves in the paper that in the vicinity of the zero point the meter does not seem to work exactly proportional to the rate of flow. He pointed out also a practical objection that may be encountered when the meter is arranged for practical use, namely, the question of sediment; he suggested that sediment is liable to accumulate in connection with boilers and that this would alter the real radius of the vortex chamber and thus permit a certain inaccuracy in the meter.

Mr. Nedden pointed out also that this form of meter is at a disadvantage in that it is considerably larger in diameter than a venturi tube for the same rate of flow. Also if to be used in connection with high pressure, it might be necessary to make this form of meter a great deal stronger than the venturi tube of the same rated capacity.

A. R. DODGE referred to a point of interest in connection with the formula of the calibration curve [1], which indicates that the loss of head varies as the square of the velocity in accordance with the same formula on other meters, the pitot tube meter and the venturi meter. He questioned if this is so, if the Hayes' meter is not of the same sensitiveness at low flows as the venturi meter or the pitot tube meter; that is, if the size of the instrument will not determine the constant.

Another point to which Mr. Dodge referred was the fact that the drop in pressure on a pitot tube meter is negligible, but that with the Hayes' meter the pressure drop is a considerable item.

CARL SMERLING asked if Mr. Hayes had attempted to measure gasoline with these meters. He pointed out the difficulty of the problem of measuring gasoline correctly in a meter and predicted a big field for a meter of this type if made available for gasoline.

THE AUTHOR, in answer to Mr. Nedden, pointed out the original meter, which is the first model he made, and suggested that it was more of the shape to which he referred. He admitted that there was much less loss of head in that model, but he stated that the reason he made the second form was to measure the loss of head which he could not measure on the first one; he did not get enough to measure. He said his desire had been to obtain enough loss of head to be able to measure it and also to get the stream lines coming out straight. He told how he had changed the form of meters since then including some changes in the neck, and that the loss of head had been materially reduced.

In reply to Mr. Dodge, he said that apparently the sensitiveness of the vortex meter is almost independent of the size of the chamber. While theoretically it would be absolutely independent, viscosity comes in and makes a little change, but that a large vortex chamber or a small one could be used and the constant would be almost the same. He replied to Mr. Smerling that the meter has been used for gasoline.

# LABORATORY FOR INVESTIGATING AND TESTING LIQUID FLOW METERS OF LARGE CAPACITY

BY W. S. GIELE, PHILADELPHIA, PA.

Junior Member

The laboratory described in this paper was designed and built[1] to facilitate the testing and standardization of liquid flow meters of the V-notch weir and other types.

As made by the company at whose plant the testing laboratory was erected, the V-notch meter is combined with a feed water heater of the open type and is provided with an autographic recording and integrating device. A float resting upon the surface of the water in the approach chamber bears a vertical stem, actuating (by means of a cable and drum) a revolvable cam, adapted to displace a pen carriage or integrating train equal distances for equal increments in the rate of flow. The cam embodies the relation between the rate of flow and the head of water on the notch and the adaptation to different rates of flow is accomplished by varying the diameter of the drum upon which the cable winds and the angle of the notch itself, thus making it necessary to establish the relation between the coefficient of the notch and the angle.

The rate of flow through a flow meter may be computed by measuring, either gravimetrically or volumetrically, the quantities discharged during a known period. Such a method, however, involves starting and stopping errors, errors in maintaining the rate of flow constant for the whole period of test, in keeping a record of the exact variations of head or pressure, and in obtaining exact time readings on short runs.

To eliminate the errors involved in the above method, a continuous flow method of test was decided upon. A master flow meter was constructed and installed and so arranged that the rate of flow could be maintained accurately at any desired value for long periods. The performance of this standard was determined with all possible precision, after which it was used to measure the flow through the meters under test. A degree of accuracy could be secured, in the meters tested, practically equal to that of the standard. Also, the latter having once been accurately calibrated, disturbing influences arising from effect of proportions of channel of approach, conditions of surfaces, form and material of notch, directions and interference of currents of flow in the channel of approach, etc., could be ignored.

By the method used, not only is the accuracy of individual tests assured, but it is possible to conduct a very much larger number of tests and thus confirm the work done and take advantage of the law of averages.

[1] At the Harrison Safety Boiler Works, Philadelphia, Pa.

Abstract of paper and discussion presented at the Annual Meeting, December, 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

### DESCRIPTION OF APPARATUS

The testing plant has a large sump or storage tank from which the water is drawn and elevated to a constant head supply tank at the highest level, as shown in Figs. 1 and 2.

The purpose of the constant head tank is to supply water to a discharge orifice at a constant head so that the rate of flow through the standard notch may be maintained invariable at any desired capacity.

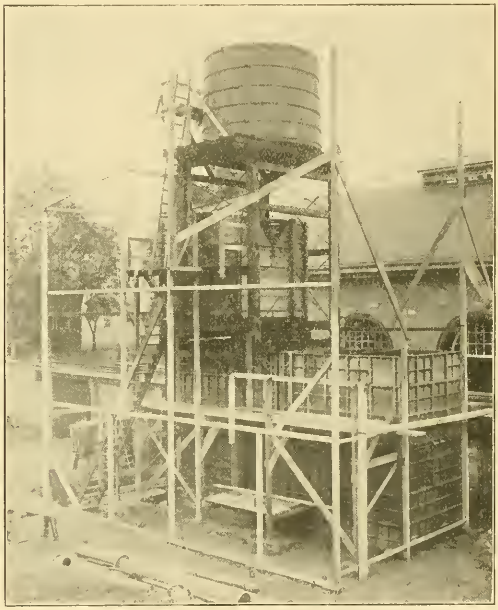

Fig. 1 Meter Testing Plant

From the constant-head tank, the water passes to the standard-notch tank, thence over the calibrated standard notch into the meter under test, whence it is discharged to the storage tank to circulate again.

The two volumetric measuring tanks, shown in Fig. 2, were used in the preliminary work of calibrating the standard notch, and afterwards served as catch basins for the water discharged by the meters under test. The capacity of these tanks is approximately 525 cu. ft. each.

The entire plant was constructed with the utmost regard to permanency and rigidity. The foundation consists of a concrete slab carried to solid clay soil and reinforced in all directions by 1-in. rods.

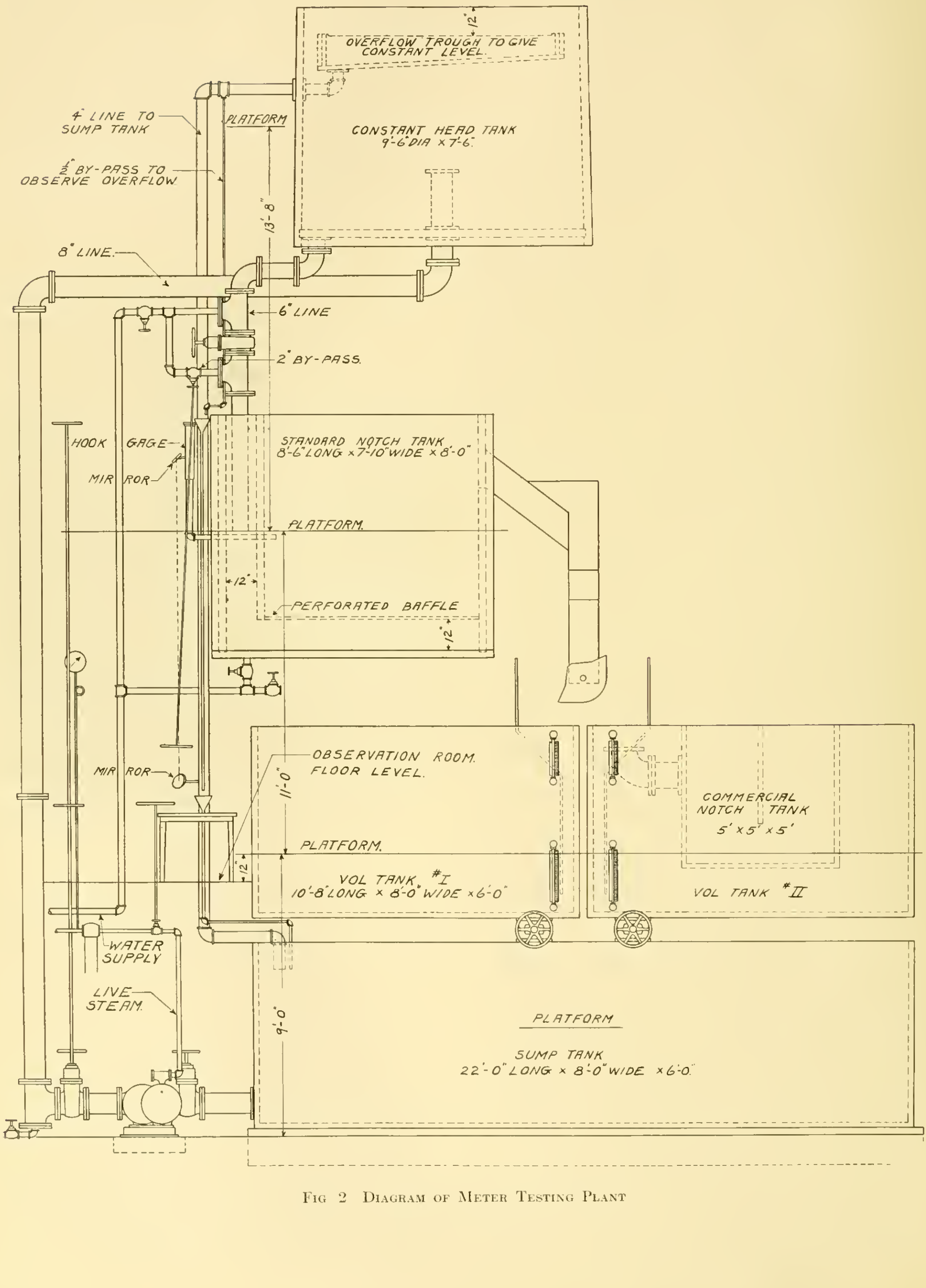


Fig 2 Diagram of Meter Testing Plant

The storage tank rests directly on the concrete foundation and holds a little over 1000 cu. ft. of water. The pump connection is located above the bottom of the tank to prevent sludge being drawn into the pump. The tank is supplied with a drain and washout, and with a system of steam pipes whereby the water may be heated to any desired temperature.

The pumping unit is an 7-in. DeLaval single-stage centrifugal pump. It is gear-driven by a single-stage DeLaval steam turbine, and its capacity is about 120 cu. ft. per minute against the head of the highest tank, which corresponds to a flow of about 450,000 lb. per hr.

The constant head tank is supported on a grill of structural steel carried by rigidly braced heavy columns resting on one of the volumetric measuring tanks. A constant head is maintained in this tank by means of an overflow weir at the surface of the water in the tank. This weir consists of a rectangular trough having inflow edges or weirs on both sides constructed of metal. An overflow is maintained over these edges throughout all experiments and is carried back to the storage tank, the line being provided with a bypass discharging into open funnels on both the standard notch level and the observation room level so that the observer may constantly watch the overflow. The approximate amount of water in the constant-head tank is indicated by a float to which is attached a chain passing over sheaves and extending to the pump room with pointers at each level.

The pipe line from the constant head tank to the standard notch tank contains a 6-in. valve for roughly setting the larger flows and a 2-in. by-pass valve carried around the larger valve for fine adjustment of flow.

The standard notch tank was rigidly constructed and is supported on columns carried outside the volumetric measuring and storage tanks directly to the foundations, the column loads being distributed on the foundation by two 15-in. I-beams grouted in. The tank is divided into two compartments by a rigid partition. The supply line discharges behind this partition 2 ft. below the surface of the water. The water spreads out over the bottom of the tank and rises through a perforated baffle, resulting in a quiet surface of approach for the standard notch.

The standard V-notch, Fig. 3, is approximately $22\frac{1}{2}$-in. high by $11\frac{1}{4}$-in. wide at the top. Its full capacity at $18\frac{1}{4}$-in. head is roughly 110 cu. ft. per minute. Owing to the method of calibration, it was not necessary to find the apex or zero level of the notch with extreme precision, only to provide a reference point immovable with respect to the notch itself from which measurements could always be taken.

In order to detect any possible deflection of the standard notch tank due to the weight of water carried, four special gages are provided at each of the four corners of the tank. The geometrical center of the four positions was located and exactly symmetrical pipe connections were carried from each gage to a common opening at this center.

The level of the water flowing through the standard notch is obtained by means of a specially designed hook gage connecting with the still-water chamber. The unusual construction of this hook gage arises chiefly from the extreme range of height which it must cover and the consequent possibilities of error resulting from differences in temperature both between its

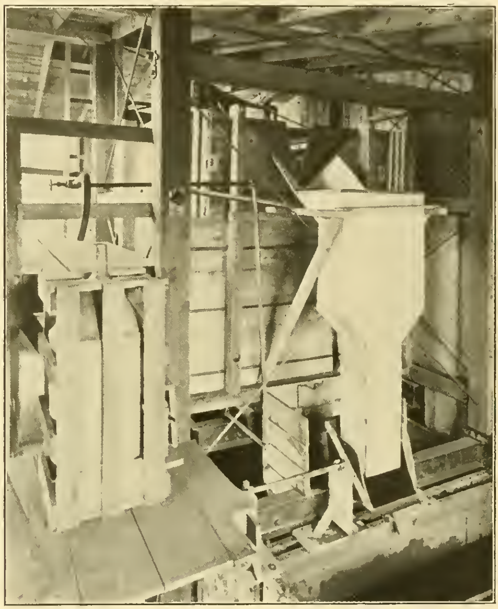

Fig. 3 Standard V-Notch used in Testing Plant

various parts and between the water column within the gage tube and the water in the still-water chamber. To eliminate the former, the gage elements are so constructed that expansions due to increased temperature tend to compensate each other, and to eliminate the latter, the hook gage tube is jacketed by flowing water taken from the same source of supply as that to the still-water chamber. The hook gage is shown in Fig. 4.

The hook gage system is aligned by gravity, and prevented from rotation by loosely fitting guides. The hook rod is suspended on a phosphor bronze cable which passes over a very accurate sheave running on a hardened axle. From the sheave the cable passes over a drum on the same shaft with the graduated wheel by means of which the settings are made and the readings taken. This wheel is 18 in. in diameter, and its circumference is graduated in units, each rep-

resenting 0.02 in. It has been entirely feasible with these graduations to estimate a movement of 0.0025 in. of the hook.

The register of the point of the hook with the surface of the water is observed from below the water surface, in which position it is possible to see both the hook itself and the reflected image on the surface of the water. The reading is taken through a magnifying lens and reflected downward and horizontally

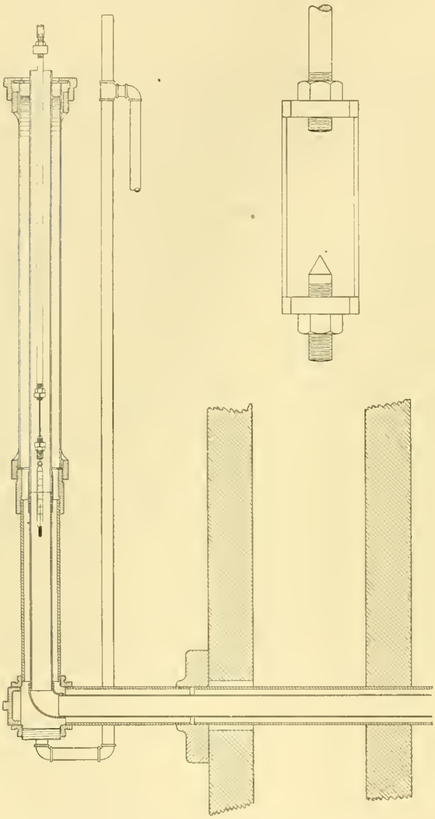

Fig. 4 Diagram of Hook Gage and Column

to the observation station, at which point a four-power binocular is rigidly supported for observation of the image. Optical distortion is eliminated owing to the reduction of illumination incident to this magnification. The hook itself is illuminated by means of a frosted incandescent bulb.

After passing the standard notch, the water is guided into a large funnel and conducted to a tipple by means of which it may be directed into either of the two volumetric measuring tanks, or into a meter under test. The tipple is arranged with electrical contacts to ring a gong when it is thrown over to facilitate the taking of time readings.

Owing to the number of readings to be taken and the amount of space covered by the plant, special means are necessary to bring all observations and controls to a central observation room. Fig. 5 shows this room and the desk from which observations are taken, as well as the binoculars and system of mirrors by which a magnified image of either the hook gages on the meter under test, or the hook gage on the standard-notch tank may be observed. It also shows the means for observing the level of the water in the constant-head tank, the overflow from the constant-head tank, the steam pressure in the steam line to the turbine and in the turbine nozzle chamber, from the operator's station: and how the steam throttle of pump, discharge valve and by-pass valve controlling the rate of flow from the constant-head tank to the standard-notch tank are all within the reach of the operator.

## POSSIBLE ERRORS—TYPICAL TESTS

In the part of the paper which follows, an idea of the accuracy of the work is conveyed by assuming conditions very much worse than occur in operation and calculating the resultant error.

For instance, if the pump can be controlled only within a variation of discharge rate of, say, 166.8 cu. ft. per hour, and if the head of water over the overflow weir in the constant head tank is 0.2 in. (corresponding to an overflow of 7.26 cu. ft. per minute) an increase in the delivery rate of the pump of 166.8 cu. ft. per hour increases the overflow head to 0.245 in. This increased overflow would increase the head to the valves through which water is admitted to the standard notch tank (which is 10 ft.) from 10.0166 to 10.0204 ft., and the variation would be as the square roots of these two heads, or not more than 0.015 per cent.

The effects of error in the various elements of the hook gage are analyzed in the paper. While with the water jacket described, it was never possible to detect a difference in temperature between the water in the hook gage tube and in the still-water chamber exceeding ½ deg. fahr. during the course of a whole day, it is interesting to note the results which might be obtained from an unjacketed gage. Without the jacket water, it was found that a difference of 20 deg. fahr. (from 50 deg. to 70 deg.) was entirely possible and affected a vertical head of 30 in. of water. The reading of the gage under such conditions would be 0.048 in. in error. Fig. 6 shows the percentage error in flow due to error of 0.005 in. in hook gage reading.

The paper concludes with a description of the methods used in calibrating the apparatus and outlines the procedure in conducting a typical test.

The method of conducting typical meter tests in this laboratory is to set the meter into one of the volumetric measuring tanks so that it will receive its

supply from the standard notch and so that the volumetric measuring tank will catch its discharge simply as a catch basin and return it to the storage tank. The head of the standard notch, corresponding to the desired rate of flow for which is desired to find the head in the meter under test, is read from the larger scale curve and the hook gage on the standard-notch tank accordingly set. The flow through the system is then brought to the desired rate by controlling the water level in the standard-notch tank to the point of its hook gage. When conditions have become stable the head over the notch under test is read by means of its hook gage.

In running tests, it is necessary only to observe that the water level remains at the point of the gage on the standard notch and it is not necessary to read the height of the hook gage on the standard-notch tank during the progress of an experiment. The hook gage applied to the meter under test is provided with an extended shaft, bringing the graduated scale to the observation room where the operator can read the height of water passing over the weir under test. This reading is taken immediately above the eye pieces of the binoculars through which is observed the coincidence of the water surface and the hook.

## DISCUSSION

H. E. Ehlers asked whether any experiments were made to determine how much variation existed in the surface of the water in the V-notch tank. He said the quantity flowing over the notch is determined by the hydraulic head back of the notch, and while it may be entirely possible to measure the level in the hook gage to an accuracy of 5/1000 in., he would like to know how nearly uniform the water level in the tank itself remained.

He referred to the assumed error of measurement of the head in the two large standardization tanks of 3/100 per cent at the higher rates of flow. The maximum flow is about 110 cu. ft. per minute, which allows about 5 minutes only for the filling of one of these large tanks. He asked how still the surface of the water in these tanks became. He said his own experience had been that water flowing into tanks under such conditions causes disturbances and pulsations which take a considerable time to die out. The surface may become smooth but it continues to rise and fall or pulsate.

Most of these meters, he said, are used for metering hot water, and the statement is made that the storage tank is provided with a system of steam pipes for heating the water to any desired temperature. A meter of this type measures volume, which is converted to weight by a direct coefficient. The weir is calibrated at 70 deg. or ordinary temperatures and a cam is worked out which is intended to give a rating in pounds. If the temperature of the water is raised to say 210 deg., its density is changed and so is the depth of immersion of the flow used to indicate the head of the weir. The first change is constant, but the second change is a variable and also has a much greater effect at low heads than it does at high heads. He asked how these weirs are calibrated for temperatures as high as 210 deg.

George H. Gibson contributed a written discussion of which the following is a summary:

Two considerations favor the general adoption of the V-notch as a boiler feed meter. The first is its sensitiveness at small flows and the second its simplified construction made possible by assuming that the rate of flow is proportional to the 5/2 power of the head. This law is not strictly true even under ideal conditions, but its assumption facilitates the construction of float-actuated cams to move the recording pens.

Fig. 5 Observation Room

The numerous combinations of different notches with weir chambers of various dimensions required such a number of calibrations as to render volumetric and gravimetric methods tedious as well as expensive. To obviate this, the elaborate testing plant described was constructed and by its means the manufacture of V-notch meter chambers has been standardized.

In answer to Prof. Ehlers, Mr. Gibson said that the sensitiveness of these meters at small flows is not a matter of the operation of the notch itself. Overcoming the friction of the translating cam consumes such a large fraction of the power available for operating the recorder as to render impossible the measurement of differences in head at these flows to great accuracy. This is particularly true

in the case of the venturi meter in which reducing the flows to 1/4 reduces the velocity head to 1/16; below this flow great accuracy with this meter is out of the question.

J. H. MORRIS gave some personal experiences in a manufacturer's water meter testing plant regarding the difference in level in the filling tanks. The weir in this plant is flat-crested and is 8 ft. in width. When running at approximately a foot head, the differences of level in the weir chamber is not more than 2/100 ft. provided the stream is properly baffled as it enters the chamber. The constant head is obtained by a centrifugal pump driven by an electric motor, the differences in head being obtained by varying the speed of the motor. In a pressure chamber into which the pump delivers, the differences in head caused by the vibrations due to the action of the pump register from 1/10 ft. to 5/100 ft.

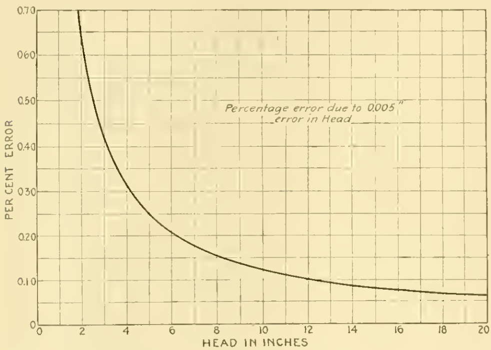


FIG. 6 CURVE SHOWING PERCENTAGE ERROR IN FLOW DUE TO ERROR OF 0.005 IN. IN HOOK GAGE READING

THE AUTHOR in replying to Prof. Ehlers said that the relative error at various heads due to the same error in reading the head, or what corresponds to the same thing, the error between float and cam in various positions, is shown in Fig. 6. The correct method to compensate for this error is believed to be by measuring the force required to move the recorder and then to so proportion the water line area of the float that the latter will displace an amount of water proportional to this force. In this way it is possible to take full advantage of the greater relative accuracy of the V-notch at small rates of flow. Considerable trouble was experienced in getting the surface of the water in the standardization tank and in the volumetric tank quiet, but disturbances in these tanks are now controlled even with the rapid passage of water. Variations in the surface of the water in these tanks were shown by the gages in their corners.

He said that most of the other points raised by Prof. Ehlers had been covered by Mr. Gibson.

In a V-notch meter there are so many variables, each affecting the other, that it seems best when making commercial meters of this type to build each meter as nearly correct as possible, test it under its working conditions, and make the results of this test standard for that meter.

# A NEW VOLUME REGULATOR FOR AIR COMPRESSORS

BY RAGNAR WIKANDER,[1] PITTSBURGH, PA.

Non-Member.

The variation in the consumption of compressed air being delivered by an air compressor necessitates some means of regulating the delivery in order to keep the receiver pressure as nearly constant as possible.

A number of regulators, governors or unloaders have been designed for this purpose and the object of this paper is to describe a new method serving the same purpose in a simple and efficient manner.

The existing volume regulators and their limitations and shortcomings which have led to the development of this new device are first reviewed, as follows:

A simple method for regulating the intake air is to vary the speed in proportion to the air consumption. For compressors driven by duplex or cross-compound steam ends this method is used to great advantage, the speed variation being, as a rule, obtained by means of a "speed and pressure governor," which acts upon a valve throttling the inlet steam. For compressors driven by single or tandem compound steam ends this method proves less advantageous, because the speed cannot be reduced below a certain value without excessive reduction of the flywheel effect.

A similar regulation between certain limits can be obtained by starting and stopping the compressor as soon as the air in the receiver pressure sinks below or rises above certain values. This method is suitable for small motor-driven compressors, but for larger motor-driven compressors it is, as a rule, not advantageous. In all cases, frequent startings of an air compressor under load are very hard on the transmission organs. In cases of belt-driven compressors, a belt shifter, automatically operated by air pressure, is sometimes used with a tight and loose pulley.

The choking intake unloader is in very common use. It consists of a choking valve placed in the suction pipe of the compressor and influenced by the receiver pressure. The advantages of this unloader are simplicity and gradual operation. Its disadvantages are waste of power, carbonization of the lubricant due to the great heat generated in the compressor cylinder when working on partial load, and the danger of explosion produced by such carbonization. If the unloader is arranged to open or close the intake entirely, the gradual unloading is sacrificed but the loss of power is avoided. The fact that this unloader is in common use, in spite of these great drawbacks, shows the need of a good and simple volume regulator.

[1] Hall Steam Pump Co., 918 St. James St.

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

Regulation can be secured by variation of the cylinder clearance. This method is distinctly superior to the choking inlet method. In a well-known application, two clearance pockets are provided in each end of each cylinder, and automatically operated valves put one or more of these pockets in communication with the cylinder. The receiver pressure controls these various valves so as to regulate the volume of air pumped. The drawbacks of this system are high cost, extra space required, complication and limited number of efficient capacities of the compressor.

A fourth method of regulation is by keeping either the suction or the discharge valves open by force. If the former, some of the air drawn from the suction pipe during the suction stroke will return to it during the discharge stroke. If the latter, compressed air will enter the cylinder during the suction stroke and keep the suction valves closed, allowing no intake air to enter the cylinder. The first method is in common use all over the world, and it is possible to reduce the capacity of the compressor to one-half by keeping the suction valves at one end open by force all the time. The objections to this system are again high cost, complication of parts and the limited number of efficient capacities.

The best known type of unloaders on piston type compressors with positively moved valves operate to hold the suction valves completely open for a short time as soon as the air pressure exceeds the desired limit, and permit them to operate normally as soon as the pressure sinks. Several systems are, however, in use in which positively moved valves connect the cylinder with the suction pipe during a shorter or longer part of each discharge stroke. Both these systems operate satisfactorily and their only drawbacks are to be found in the high cost and rather complicated mechanisms required.

The object of the new regulator, which is called the Hall Volume Regulator, is to provide (in case of a piston-type air compressor with poppet valves) a simple, efficient and inexpensive means of varying the amount of intake air to correspond with the amount of compressed air being consumed.

The principle of the device is as follows: If the suction valve is held open by force after the suction stroke is completed, then on the discharge stroke a pressure is developed in the cylinder tending to overcome this force and close the valve. By a very gradual regulation of the force holding this valve open, its closing at an adjustable point of the discharge stroke is obtained.

The regulator is shown in Fig. 1. *A* is the compressor cylinder. *B* is the suction valve provided with a spring tending to close it. *C* is a piston, the action of pressure on which is to tend to hold the suction valve open. *D* is an auxiliary tank connected with the main receiver *F* through a port *G*, and with the atmosphere through the leak *E*. *H* is a pilot valve which closes the port *G* when the force exerted by an adjustable spring on the valve piston *I* overcomes the air pressure on its bottom. *J* is an adjustable needle valve which can be set to obtain a constant leak from the main to the auxiliary reservoir, thereby preventing the pressure in the latter from decreasing below a certain value.

When the compressor is working at a constant partial load, the pressure on the piston *C* is kept practically constant by admitting through the valve *H*

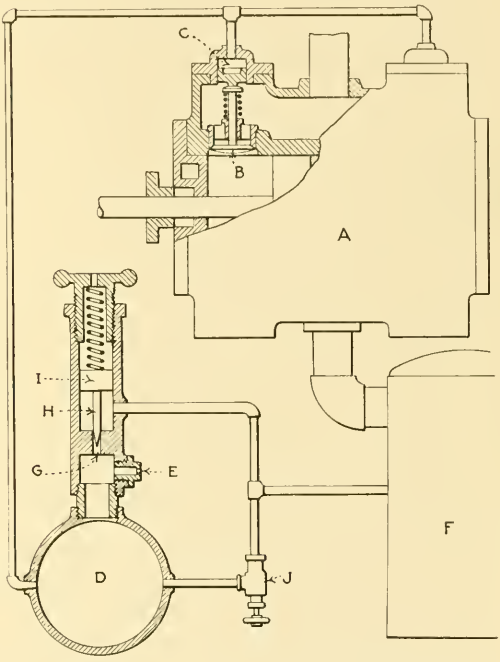


Fig. 1 Application of Regulator to an Ordinary Poppet Valve Air Compressor, showing Regulation by Action on the Suction Valves

into the tank *D* an amount of air equal to that escaping through the leak E. The suction valve then closes at such a point of the discharge stroke as to compress exactly the quantity of air consumed, the pressure in the main tank remaining constant.

An increase (or decrease) in the consumption of air will cause a slight momentary decrease (or increase) of the pressure in the main tank and of the quantity entering the auxiliary tank. This will decrease or increase the pressure in the auxiliary tank and change the cut-off of the suction valves so as to increase or decrease the amount of intake air until new conditions of equal supply and consumption are established.

The object of the valve $J$ is to admit constantly so much air to the auxiliary tank as will cause the compressor to work at its maximum capacity for which a certain pressure in the auxiliary tank is necessary. If more air is admitted, the capacity of the compressor is reduced.

The same principle can be also applied to the regulation of the discharge valves of a piston inlet type of compressor, when it operates to close this valve at an adjustable point of the suction stroke. This application is described and illustrated in the paper, as is also a method of electrical control of the regulator.

It is claimed that the regulator can be applied with advantage to single or tandem compound steam driven compressors, being easily operated in connection with the ordinary speed and pressure governors. The device is also stated to be especially applicable to gas engine driven air compressors and to natural gas compressors in gas pumping plants where the pressure varies on account of field conditions. A chart is given showing the comparative power consumption and quantity of free gas pumped per minute by a 17-in. cylinder compressor without and 20-in cylinder compressor with the Hall regulator.

The paper concludes with a number of indicator diagrams taken from a standard Hall poppet valve air compressor equipped with this regulator.

## DISCUSSION

W. L. SAUNDERS, in a written discussion, stated that he regretted the author had given so little space to the system of clearance unloaders or controllers, which the writer claimed to be not only extremely simple and inexpensive, but had been demonstrated to be highly efficient.

He stated the cardinal requirements for the successful operation of a regulator for high speed compressors operating at constant speed are:

First, underload regulation must be obtained with such a degree of economy that the reduction in power required will be practically in a direct proportion to the reduction in output capacity.

Second, all mechanisms for regulating the compressor must be independent of the running gear of the compressor, otherwise the timing of the regulator as the regulation varies is difficult to accomplish, and the delicate yet durable mechanism required, operating at the full speed of the compressor continuously, is extremely difficult to design and manufacture. The difficulty and cost of maintenance and the shut-downs requisite for repair have proved excessive when the regulating mechanism is part of or dependent upon the running gear of the compressor.

Third, the regulator should be of such design that, when the compressor is called upon for average operation at partial load capacity, it can be so adjusted by hand as to limit the maximum capacity, and thus permit the compressor to operate at a higher average capacity or higher load factor than would otherwise be possible. This is a valuable feature under conditions where electric power service is furnished under a special maximum demand charge.

He stated that with the automatic clearance controller the inlet capacity of the compressor is reduced without reducing the intake pressure. On a two-stage compressor a constant ratio of compression throughout the entire load range, and the highest compression efficiency, is maintained throughout. The reduction in power secured with this method of control is practically in direct proportion to the reduction of load. The regulator is simple in construction and entirely automatic in operation.

On account of its under-load economy, the automatic clearance type is in his opinion of value in the majority of conditions of constant speed power-driven compressor service requiring under-load regulation.

JOSEPH ESHERICK wrote congratulating the author upon his excellent paper and for his work in developing the Hall volume regulator.

In regard to volume regulators, he said the author made no mention of the Richards Pressure Unloader. This unloader permits the compressor to run unloaded until the desired speed is obtained, when it loads the compressor automatically. The device is placed in the discharge line between the compressor and receiver and is simple and inexpensive. It is used primarily on motor-driven compressors. Another type, called the Initial and Pressure Unloader, has been designed for continuous running steam and electric-driven compressors. This embodies means of adjustment for any degree of regulation, from two to fifteen pounds.

One of the chief advantages of the Richards unloaders is that they permit, while the compressor is running unloaded, the passage of free air through the cylinder, with its resultant cooling effect on these parts.

PAUL DISERENS wrote that the author's objection to the choking unloader were well taken as directed against its application by gradual throttling, but that this application was practically obsolete. They were not well taken in the case of the total closure unloader, which is both safe and efficient when properly protected by atmospheric relief valves. The only drawback to the total closure unloader is the sudden change from full load to no load it causes, but where this is not objectionable at the electrical end the device answers very perfectly.

Theoretically the principle of varying the capacity of a compressor at constant speed by changing the clearance (clearance unloaders) is sound. The writer sees, however, the chief objection to the practical application of this principle for volume control in the obstruction to free communication between cylinder and clearance chambers occasioned by the restricted valve openings, of necessity interposed between cylinder and valve pockets.

The author's comment on unloaders on compressors with positively moved valves implies that unloaders operating the suction valves are the best type, whereas one of the most widely used devices of this nature involves an auxiliary by-pass valve and connections.

The volume regulator which is the subject of the paper appears to depend on the gradual increase, during the entire length of the compression stroke, of the cylinder pressure as compared with the suction passage pressure, but it does not seem clear why such gradual increase should occur.

It would also appear that on compressors of medium and larger sizes, operating at the relatively high speeds now generally employed, a multiplicity of valves equipped with by-passing control would be needed. This would appear to present some difficulty in synchronizing their action.

The application of the regulator described to a two-stage compressor necessitates the use of two independent governors, one to regulate the line pressure and the other the intercooler pressure. Though this does not constitute a serious objection, it implies a complication to which the author takes exception in other forms of volume control.

James Tribe expressed his written opinion that the form of valve to which this regulator was shown applied might operate with fair success under low-speed conditions such as formerly obtained, but in modern compressors running at say 150 r.p.m. such a valve must have a very short life. Even the pressed steel cup valve, used for many years by the best builders on account of its lightness, was proving too massive to withstand the shock incident to valve action with high speeds.

An air compressor invented by Mr. G. H. Reynolds in 1876 and disclosed in U. S. Patent 187,906 embodied the principle of by-passing air from the cylinder to the external air on the compression stroke when the receiver pressure was increased above a certain limit. This invention, long since abandoned on account of the changing conditions of practice, was similar to the Hall regulator in that the receiver pressure controlled valves in the cylinder for unloading the compressor automatically.

Several large compressors recently built by the Allis-Chalmers Company have been equipped with unloaders embodying the Reynolds principle but reversed in application. These unloaders are independent of either the inlet or discharge valves and are not influenced by the speed of the machine.

John Glass[1] contributed a written discussion in which he said the Hall regulator would not apply to a pipe line as to a tank, as it is not practical to carry a constant discharge pressure at the various compressing stations of large gas-pumping plants. In such installations, the gas pressure is partly regulated at the compressing plant closest to the point of consumption, but the other plants back on the line are run at constant speed, that is, compressing all the gas possible. If more pressure is required in the line extra wells are turned in, and if the unloading device is affected by this, shortage of gas will occur at the consumption end.

He thought that this regulator was well adapted to gas engine driven compressors, especially in starting, and also on account of the limited capacity of the gas engine for overload, but that it was not of very great advantage in gas-pumping plants, as the changes in pressure are too great. When the field pressure drops the discharge drops also, giving about the same number of compressions. A large diameter compressor would be a disadvantage as the speed would have to be reduced so as not to exceed the economical number of compressions, about 4.5.

The facility with which the regulator could be applied he considered to be of importance.

[1] Chief Engineer, Carnegie Natural Gas Co., Pittsburgh, Pa.

Frank Richards said that the device described could only be used in connection with obsolete or obsolescent types of inlet and discharge valves. He said we have learned that poppet valves are by no means the best for air compressors. The poppet valve has considerable inertia, and moreover the resistance of a spring has to be overcome in opening it; oil gums its guides and the valve requires frequent examination and cleaning; it gives a more or less restricted and tortuous passage for the air, and this feature is accentuated when the air has to play back and forth for regulation purposes. With this valve, too, the pressure of the air within the cylinder is necessarily lower at the beginning of the compression stroke than that outside.

The Corliss inlet valve, wide open for nearly the entire stroke, and with large port area and a direct passage for the air into the cylinder, gives a freer inrush to the air and a fuller pressure at the beginning of the compression stroke.

The Rogler valve, which has replaced the poppet valve, annihilates its objectionable features without entailing others. This valve consists of a very thin steel plate covering concentric annular openings in the valve seat, and with a minute, free lift it gives the largest and freest passage for the air that has ever been realized. The Hall regulator cannot be applied to either this or the Corliss valve.

The regulation of a compressor should be accomplished without interference with its ordinary operation, and so it might be well that neither the inlet nor the discharge valves should be interfered with for this purpose. This may be secured by controlled changes of the cylinder clearance, an almost ideal mode of regulating the output from nothing to full delivery. It is possible mechanically to have an automatically pressure-adjusted changeable clearance for the air cylinder so large that at one extreme of its capacity a whole cylinderful of free air shall, when compressed up to receiver pressure, just fill this clearance space and none be expelled to the receiver. Then the compressor could run along continuously, and the air in the cylinder would be alternately compressed and re-expanded and no power expended.

A partial reduction of this clearance space would compel an expulsion or delivery of a portion of the air, and the remainder would re-expand upon the return stroke the same as with the clearance of full capacity, but in the latter case at the end of the stroke a portion of free air would be taken in sufficient to replace the volume delivered, and so on. With this adjustable clearance reduced to its minimum, the cylinder would be delivering its full charge of air, and its action would be entirely normal.

Such a clearance control is not yet fully realized, but the four stage clearance controller already in extensive use gives highly satisfactory results in practice. The only expense it involves is its initial cost, as it requires no constant operating expense.

The Author, in his closure, said that although Mr. Richards referred to poppet valves as being obsolete or obsolescent, he was of the opinion that almost 90 per cent of the compressors used in this country were fitted with this type of valve.

In reply to Mr. Glass, who stated that a volume regulator operating with constant pressure was not needed in large gas pumping plants, the regulator described is not limited to constant pressure, as it can also be operated to give any constant volume desired. In the ordinary practice, a gas engine driven compressor is built so small that the engine can pull it under any conditions. With the regulator described, the gas engine can be built just large enough to take care of the ordinary conditions, and the amount of intake gas so regulated that the work required for its compression corresponds to the capacity of the gas engine.

In reference to the criticism by Mr. Tribe of the novelty of this regulator, the author stated that investigation had established the existence of only one prior invention of similar character. This was the subject of a patent to Mr. E. A. Rix in 1900 (U. S. Patent No. 602,170), in which a positively moved system of levers, similar to the Corliss valve gear, operated to close the inlet valves of a compressor at some point of the compression stroke varying with and dependent upon the pressure in the outlet pipe or its connection.

## DAMAGES FOR LOSS OF WATER POWER

BY F. W. DEAN, BOSTON, MASS.

Member of the Society

When the water of a stream is diverted at any point, damages for loss of power must usually be paid to any mills having a water power plant located below the point. Cases are frequently heard before a commission, occupy much time, involve considerable expense, and the testimony is widely divergent. Some of the questions about which such testimony differs are discussed in this paper under the heads: Determination of value of water power, rate of capitalization, proper development of water power, method of estimating average yields, proper auxiliary engine to install, kind of coal, economy of steam plants, use of existing engines and boilers to supply loss by diversion, efficiency of water wheels, friction of water wheel gears and shafts, developed and undeveloped powers, and value of water for non-power purposes.

It is now generally understood that the determination of the value of water power takes into consideration the cost of making power by steam which may be spoken of as the standard for comparison. This value is the capitalization of the annual saving by the use of water power. The mill can be operated by the water power combined with a proper steam plant to produce uniform power throughout the year, or by the best adapted steam plant. The costs may be tabulated in a general way as in Table 1. If the amount

Abstract of paper and discussion presented at the Annual Meeting, December 1914. Complete paper may be obtained without discussion, price 5 cents to members; 10 cents to non-members.

TABLE 1 GENERAL COSTS OF POWER BY STEAM AND BY WATER

| Annual Costs of Power by a Steam Plant | Annual Costs of Power by Water Combined with Steam Sufficient for a Uniform Power | |
|---|---|---|
| | Water Power Plant | Auxiliary Steam Plant |
| Interest | Interest | Interest |
| Depreciation | Depreciation | Depreciation |
| Insurance | Insurance | Insurance |
| Taxes | Taxes | Taxes |
| Attendance | Attendance | Attendance |
| Fuel | .................. | Fuel |
| Supplies | Supplies | Supplies |

of the first column exceeds that of the sum of the second and third, the water power has value.

The theory in a water power damage case is that the award shall be such that the interest thereof shall be sufficient to equal fully the extra expense caused by the diversion. This rate is usually taken at 5 per cent, but is a subject of argument.

In the case of an undeveloped power a higher rate of capitalization may be used as a means of scaling down the value and as representing the necessary profit of an enterprise.

Water powers are seldom developed to the power of the wet months, but to the average power of the eighth or ninth month when the stream flows are arranged in the order of wetness.

A water power produced by the unassisted natural flow of the stream is of very little value when developed to the customary extent since the largest yield in a given period is often many times the smallest yield (Table 2).

TABLE 2 AVERAGE YIELD OF WATER SHED

| Months in Order of Wetness | Yields in Cubic Feet per Second per Sq. Mi. of Watershed | | |
|---|---|---|---|
| | Sudbury River, Average of 37 Years | Nashua River, Average of 15 Years | Little Westfield River, Average of 6 Years |
| 1 | 2 | 3 | 4 |
| Dryest | 0.137 | 0.330 | 0.22 |
| 2nd dryest | 0.232 | 0.492 | 0.37 |
| 3rd dryest | 0.386 | 0.633 | 0.47 |
| 4th dryest | 0.546 | 0.802 | 0.81 |
| 5th dryest | 0.707 | 0.939 | 1.00 |
| 6th dryest | 0.929 | 1 106 | 1 37 |
| 7th dryest | 1.156 | 1.319 | 1.64 |
| 8th dryest | 1.574 | 1.718 | 2.59 |
| 9th dryest | 2.188 | 2.283 | 3 24 |
| 10th dryest | 2.746 | 2.764 | 4.32 |
| 11th dryest | 3.518 | 3.542 | 5 42 |
| Wettest | 4 776 | 4.654 | 7.21 |

Areas are frequently available in the watersheds that can be dammed and overflowed in the wet months. This is a saving feature of water power development of great importance, but probably in no case results in a uniform power. Table 3 shows the results for the average and dryest years in a case investigated by the author. Even in the smallest development, a steam plant is necessary.

In treating a water power problem, a systematic arrangement of the yields of the stream is necessary and the most convenient and effective one is that of monthly yields in the order of wetness or dryness. The calendar order is without significance.

Investigation shows that the most economical engine to install depends upon the power to be made up to produce a steady power. Between certain limits, the most economical engine is the simple non-condensing type. Simple condensing engines, compound condensing engines, condensing or non-condensing steam turbines, may be best. The greatest net economy as made up of fixed charges and costs of operation must be considered.

TABLE 3 RESULTS FOR AVERAGE AND DRYEST YEARS

| Month | Horsepowers Based on the Natural Flow of the River | | Horsepowers of 5000 h.p. Development Using Storage | | Horsepowers of 7500 h.p. Development Using Storage | | Horsepowers of 10,000 h.p. Development Using Storage | |
|---|---|---|---|---|---|---|---|---|
| | *A* | *B* | *A* | *B* | *A* | *B* | *A* | *B* |
| Dryest..... | 1340 | 130 | 4400 | 130 | 1340 | 130 | 1340 | 130 |
| 2nd...... | 2250 | 909 | 5000 | 909 | 2250 | 909 | 2250 | 909 |
| 3rd....... | 3850 | 1904 | 5000 | 1904 | 3850 | 1904 | 3850 | 1904 |
| 4th....... | 4590 | 2247 | 5000 | 4623 | 7500 | 2247 | 4590 | 2247 |
| 5th.. .... | 5100 | 2465 | 5000 | 5000 | 7500 | 2465 | 5100 | 2465 |
| 6th....... | 6000 | 2983 | 5000 | 5000 | 7500 | 5275 | 9900 | 2983 |
| 7th....... | 7200 | 4455 | 5000 | 5000 | 7500 | 7500 | 10000 | 4455 |
| 8th....... | 9350 | 5364 | 5000 | 5000 | 7500 | 7500 | 10000 | 8879 |
| 9th....... | 11200 | 7699 | 5000 | 5000 | 7500 | 7500 | 10000 | 10000 |
| 10th....... | 13500 | 9127 | 5000 | 5000 | 7500 | 7500 | 10000 | 10000 |
| 11th....... | 16800 | 9213 | 5000 | 5000 | 7500 | 7500 | 10000 | 10000 |
| Wettest. .. | 27700 | 20457 | 5000 | 5000 | 7500 | 7500 | 10000 | 10000 |

*A* = Results for the average year.
*B* = Results for the dryest year.

The make-up steam powers vary between wide limits, and judgment must be exercised as to the best type of engine to install and also its size.

The kind of coal considered in any case should be the normal coal of district. This is nearly always a bituminous coal, although the coal actually used is often a mixture of bituminous and fine anthracite.

In damage cases a great deal of testimony is given concerning the economy of steam plants. It is well known that the economies of such plants are very variable and differ from each other. In some cases great care is taken to have good plants carefully operated, while in others they are neglected and incompetent men are employed, but such plants as the latter should not be taken as criterion for basing an award for damages.

Engines and turbines may be non-condensing or condensing, simple or compound. Steam engines high in economy are being devised. Superheated steam is being introduced and may be at any time installed in mills that are damaged by loss of water. Using better condensing apparatus is resulting in improved economy. The simple non-condensing engine, the exhaust steam of which is utilized for mill processes, forms the most economical steam plant, and this is generally understood. These considerations bear upon the testimony that may be given in cases such as are under consideration.

Another feature of damage cases is that of allowing for the variable loads that auxiliary engines carry, but recent engines are not as wasteful with such loads as were engines made 20 years ago. However this may be, there is considerable uncertainty in estimates of the coal used with variable loads.

It is beneficial if in damage cases the power to be made up month by month is sufficiently small to be assumed by the existing engine in the plant. The main engine is likely to be of an economical type for the work and would in every way be more satisfactory to the damaged party by itself than in connection with an additional engine. If an additional engine is put in, the award will be larger, but the recipient will have a more expensive plant. If the existing engine cannot carry the additional load, another should be added, which is usually done if the highest award is sought.

In many cases, too, the existing boiler plant and force of firemen is ample to carry the additional load. It is better if this is so, but if not, the award should contemplate an addition.

The maximum efficiency of new and clean waterwheels has been found to be nearly 85 per cent. Testimony is often given to the effect that the average efficiency of waterwheels is as much as 80 per cent, and this is used in estimating the power lost, while an examination of efficiency curves, and contemplation of conditions to which wheels are subject, show that such an efficiency under the conditions is impossible. In the author's opinion the average efficiency used in water power damage cases should be taken at not more than 75 per cent.

The power of vertical water wheels is transmitted through bevel gears, the friction of which has been shown to be from 3 to 4 per cent. The shaft of a horizontal waterwheel, and the horizontal shaft driven through the gears of a vertical wheel, correspond with the shaft of an engine, enabling powers to be compared. The delivered power from horizontal shafts for wheels and engines, compared with the steam power is:

| | |
|---|---|
| Gross water power, per cent | 100 |
| Average power delivered by shaft of horizontal wheel, per cent | 75 |
| Average power delivered by horizontal shaft of vertical wheel, per cent | 72 |
| I.h.p. of steam engine, per cent | 100 |
| Average power delivered by engine shaft, per cent | 92 |

In the case of a developed power the problem of determining a proper award is comparatively definite. In the case of an undeveloped power, supposititious cases have to be assumed, and the award is a guess.

A knowledge of the costs of undeveloped powers is, of course, very valuable, but such information is difficult to obtain.

The determination of the value of water for non-power purposes does not usually come from the diversion of water, for when this occurs it is common to give a manufacturer as much water as he needs for such purposes, as for boilers, paper washing, dye houses, etc. Sometimes the question arises as to how much shall be paid to the owner of a source of supply for a quantity of water, or how the price shall be readjusted.

## DISCUSSION

Jay M. Whitham, in a written discussion, expressed the opinion that the range of efficiency of variable loads which have to be allowed for in damage cases, is greater than the author appears to think.

As regards the use of existing engines and boilers to supply power lost by diversion, he thinks that the market value alone must control, and also that the condemning party should pay its pro rata of operating costs in the mill. He emphasizes particularly that in all condemnation of water powers, local considerations must control, and the loss in market value must determine the result.

# PHYSICAL LAWS OF METHANE GAS

BY P. F. WALKER, LAWRENCE, KANSAS

Member of the Society

In the recent marked development of the natural gas industry in the Middle West, there has been a realization of the necessity of a greater degree of accuracy in the many technical problems which have arisen.

The compression at various points in the transmission line in order to maintain pressures giving economy in transmission, the determination of conditions of flow by line-flow formulae and the measurement of the gas purchased and sold, involve an exact knowledge of the characteristics and behavior of gas under varying pressures. Methods of dealing with these problems have been the subject of various recent articles in The Journal, and through this and other channels much has been done towards systematizing the work and establishing formulae for convenient calculation.

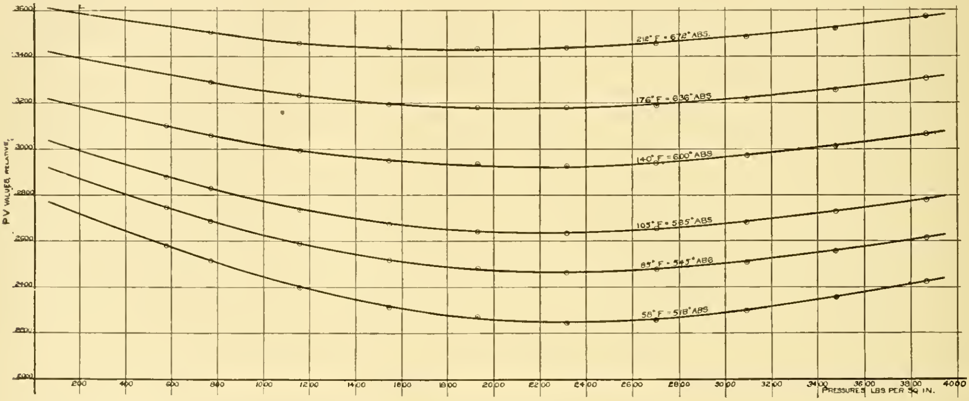


FIG. 1 *PV*-VALUES; *T*-CONSTANT CURVES ON PRESSURE, ORIGINAL DATA. VOLUMES OCCUR IN RELATIVE VALUES ONLY

In all the published matter available, calculations have been based on the laws of perfect gases. The laws of Boyle and Gay Lussac have been assumed to hold for the gas being transmitted and measured, but it is well known that this is not true.

The present paper attempts to develop a few equations which relate quantities of real significance and to establish values of some coefficients which may be applicable where a very high degree of accuracy is demanded.

The error involved in the use of the perfect gas

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Abstract of paper and discussion presented at the Annual Meeting, December, 1914. Complete paper may be obtained without discussion, price 10 cents to members; 20 cents to non-members.

laws is most pronounced in line-flow formulae and in measurement of volume. It is necessary to convert high pressure volumes to equivalent volumes under pressure at or near atmosphere. Density is always determined under atmospheric pressure, or slightly above, and it is then assumed that under widely vary-

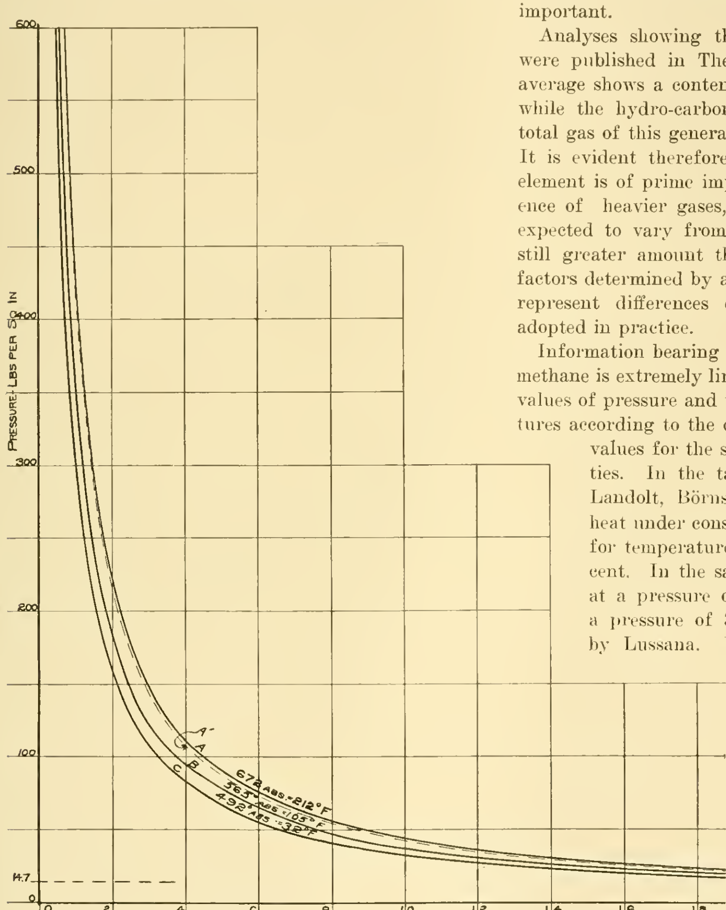



FIG. 2 *T*-CONSTANT CURVES FOR 1 LB. OF GAS. CURVE *A'* IS A PERFECT GAS ISOTHERMAL. VOLUMES OCCUR IN TRUE SCALE

ing pressures this factor will vary in a fixed proportion to the density of air under widely varying pressure. Since air contains saturated vapors which do not conform to the laws of perfect gases, serious errors may be involved in this assumption, entailing financial loss to handling companies. In many other calculations, the equation expressing the relationship between pressure and volume during the adiabatic change of state becomes of great importance. In the characteristic equation, $PV^n =$ constant, the usual value taken for $n$ is 1.26. It is to be expected that the true value is different from this, which is of considerable significance since $V$ is comparatively large. The variations from the laws of perfect gases in the case of changing temperature are developed in the paper as a step in the process of investigation, although not commercially important.

Analyses showing the composition of natural gas were published in The Journal in May, 1912. The average shows a content of over 80 per cent methane, while the hydro-carbons closely associated bring the total gas of this general character to over 90 per cent. It is evident therefore that a study of this leading element is of prime importance. Because of the presence of heavier gases, however, natural gas is to be expected to vary from the laws of perfect gas by a still greater amount than does methane, so that the factors determined by an analytical study of the latter represent differences even smaller than should be adopted in practice.

Information bearing upon the physical properties of methane is extremely limited. All that was found were values of pressure and volume under varying temperatures according to the determinations by Amagat, and values for the specific heat by various authorities. In the tables of physical constants by Landolt, Börnstein and Meyerhoffer, specific heat under constant pressure is given as 0.5929 for temperatures varying from 18 to 208 deg. cent. In the same reference, values of 0.5915 at a pressure of 1 atmosphere and 0.6916 at a pressure of 30 atmospheres are authorized by Lussana. With other physical chemists, the above authorities assign an average value of 1.1315 for the ratio of specific heats at constant pressure and constant volume. The value used here is 1.235 to 1.24. This is given by Mr. Kent. In an appendix the effect of varying temperatures on this value is considered. Another value commonly used by gas men (and in the paper, above referred to in The Journal, May, 1912) is 1.266.

Fig. 1 is a graphical representation of the $PV$ values for methane (Landolt, Börnstein, Meyerhoffer, Amagat). This shows an appreciable variation from the perfect gas, for which the $PV$ curve would follow a horizontal line.

The specific heat values for constant pressure and constant volume are both expressed in the form $(a + bt)$, the quantity $a$ differing by a fixed amount

for the two cases. It is probable that the values thus given are slightly in error because of this constant difference which represents the work done during a constant pressure change accompanying one degree change in temperature, and the change of volume for such a constant pressure change would be represented by a curve rather than by a straight line. The error involved is, however, extremely small. It should be said, that the uncertainty as to the values of specific heat is a matter of far greater importance in the actual handling of natural gas than it is in connection with a discussion of pure methane. Natural gas carries many other elements, these often being actual particles of liquid, and any attempt to use

With this set of values of $PV$ for pressures of 150 lb. to 2,000 lb., a single constant temperature curve was drawn on an enlarged scale, and the curve was extended to the standard pressure of 14.7 lb. per sq. in. Since the density of methane at this pressure and temperature is well established at 0.04464 lb. per cu. ft., the $PV$ value of 2690 gives 0.05674 lb. of gas for the weight. Knowledge of this weight now made it possible to express the volumes in absolute units. While it is true that the extension of curves outside of the observed values on these preliminary diagrams is subject to some error, the curves thus extended are of very slight curvature and are of a character well established.

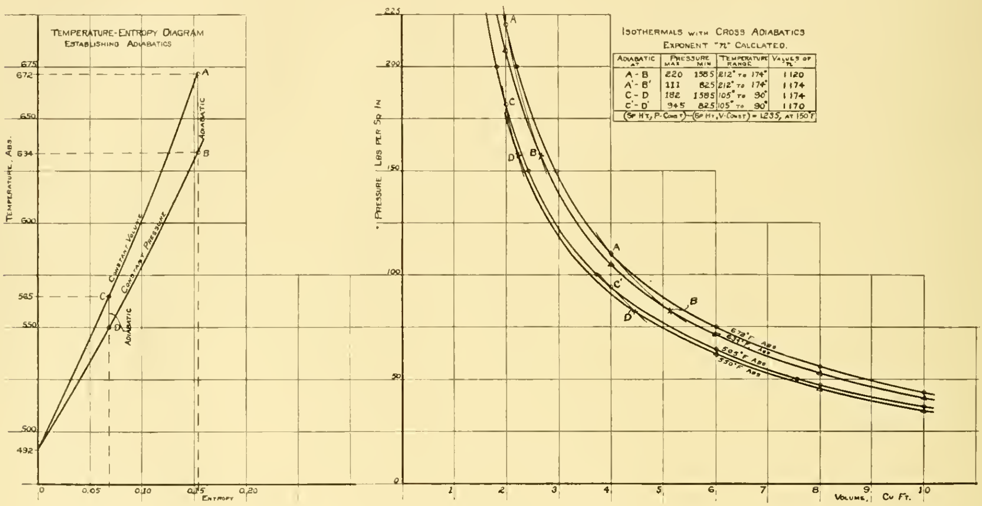



Fig. 3 Derivation of Adiabatics. All Values for 1 Lb. of Gas

measuring devices which involve a knowledge of specific heat value is subject to serious and uncertain error.

In the form in which the data for values of $PV$ occur, the volumes are given on a relative basis, making it necessary to deduce the values of $PV$ at standard atmospheric pressure and at 32 deg. fahr. in order to determine the mass of the gas dealt with and make it possible to express values on the basis of unit weight. In carrying this out, a difficulty was encountered because the values given are for high pressures only. This made it necessary to extend the curves in Fig. 1 outside the limits of observation values which could be done with fair safety to a point where values for the pressure of 150 lb. are measured. Curves for constant pressure are given in the paper establishing a set of values at 32 deg. fahr.

The isothermal curves in Fig. 2 were next laid off. $A$ and $B$ are at the original temperatures of observation. $C$ is established by the extension of curves in previous diagrams. Comparison of curve $A$ with an equilateral hyperbola $A^1$ drawn from the point of highest pressure on the curve shows that there is a noticeable variation. The gas fails to conform to Boyle's law by a significant amount when a considerable range of pressure is involved. A calculation of the equivalent volume at atmospheric pressure for a quantity of gas flowing in a line under 300 lb. absolute pressure, if made in accordance with Boyle's law, produces an error of 4 per cent. This is an item of considerable significance when large quantities of gas are being handled. These isothermal curves give a value of $n$ of approximately 0.99.

Equations connecting temperature and pressure at constant pressure have been found to be as follows:

| Equation for Constant Pressure | Equation for Constant Volume |
|---|---|
| $P = 50$ lb., $T = 75.4\,V$ | $V = 2$, $T = 2.87\,P+40$ |
| $P = 100$ lb., $T = 152.5\,V$ | $V = 4$, $T = 6.51\,P-50$ |
| $P = 200$ lb., $T = 280\,V+50$ | $V = 6$, $T = 8.80\,P$ |
| $P = 300$ lb., $T = 427\,V+50$ | $V = 8$, $T = 12.0\,P$ |
| $P = 400$ lb., $T = 539\,V+80$ | $V = 10$, $T = 15.2\,P$ |
| $P = 500$ lb., $T = 584\,V+150$ | |

Values of $n$ in the equation representing an adiabatic expansion found by the temperature entropy method are given in Fig. 3. These values are seen to be about 1.17, or very markedly below the ratio of specific heats. In much of the work in which this quantity enters it is in the form of $\frac{n-1}{n}$. When $n = 1.17$, this expression is equal to 0.145, while when $n = 1.235$, the expression equals 0.19. A value of $n$ of 1.266, commonly employed in natural gas calculations, gives the value of 0.21 for the expression. From this it is seen that in the form in which this quantity enters into much of the engineering work, the use of specific heat ratios involves an error of 30 to 50 per cent.

The paper points out the necessity for more extended work upon the specific heat and other direct factors of methane and other hydrocarbon gases to render possible tabulations of correction factors for modifying results, obtained by Boyle's and Gay Lussac's laws, for application to commercial natural gas.

Three appendices are given, two explaining the calculations used in deriving the various curves and one considering specific heat and calculation of entropy.

## DISCUSSION

Carl Smerling called attention to an interesting point in connection with the heavier ends to the deposit in the pipe lines. He had been at work on a proposition of using those ends for the liquifying of gas, for gas production in town plants through the middle west and referred to one at Sibley, Ia., which uses liquified gas at a Bonnet gravity of 86 per cent. His company had made a special distilling process for this gasoline which was a casing head or common gas process. In distilling this product, they have been able to reduce the precipitate or residue on a cold process to approximately 8 per cent., where with the old process of using casing head gasoline at 86 Bonnet, there would have been a residue of possibly 30 per cent; the latter would necessitate the emptying of the drip tanks weekly, whereas with the new process it had not been done inside of four months. He mentioned another plant in Pleasantville, Ia., where a similar plant has been used. The Sibley plant is a pipe line system of about ten miles.

The Author, in replying, said that the troubles from condensation referred to are not very serious so far as transmission is concerned. He stated that in the transmission of natural gas by compressors, it is not at all uncommon to have the liquid of condensation dripping out. By this it is not meant that methane gas changes to gasoline, but other gases, most of them of the paraffine group, which are present in the natural gas, will liquify under certain conditions. He stated that certain chemical changes are going on continually, having found in laboratory work that the chemical values are changing back and forth, either under heat treatment or under the varying pressure treatment.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

In addition to articles which can be conveniently abstracted there appear from time to time important investigations either too extensive to be used with the space available or embodying extensive tables, the reproduction of which would usually take so much space as to exclude other matter of interest. Since, however, some of these tables present matter of great interest which may be of important value to engineers in that particular line of work, an attempt will be made to present them in the form of engineering data similar to what is done in the standard engineering handbooks. In an early issue, one page will be devoted to such engineering data.

### THIS MONTH'S ARTICLES

The first article describes a portable air compressor and dynamo plant, interesting because of its compactness and good design. In the same section are described governing devices used on Swiss turbo blowers, both for constant output and constant pressure, as well as a device the purpose of which is to prevent "pumping." In the previous issue of the Journal was described a Blezinger gas producer. In this issue further data on its construction are reported and tests described. The main interest of this type of producer lies in the fact that it permits the gasification of lignites high in moisture.

An article by Stribeck is abstracted showing that the law of similarity does not generally apply to phenomena occurring in notch shock tests and that it is limited by the influences due to the crystalline structure of the metal. In the steam engineering section are described devices for removing ashes and slags from a grate by suction, without permitting dust and hot gases to escape into the outside atmosphere. Further is abstracted a report of tests carried out in the experimental laboratory of the Bavarian Association for Boiler Inspection, having for their purpose to establish the relation between load on boiler and wetness of steam in the case of a Cornish boiler where it is shown that water tube boilers produce steam of greater moisture than a tubular boiler and the percentage of moisture in the latter is less than in the former. Several new types of grates are described, among them the inclined grates with compound grate bars and an improved type of hollow grate bar.

Two papers on coal dust fired reverberatory furnaces were presented before the American Institute of Mining Engineers. Before the same Society was presented a paper describing experiments on the flow of a mixture of sand and water through spigots, giving data on the relation between composition and viscosity of such mixtures. Among other things, the paper gives a definition of the term "viscosity" as applied in the case of such mixtures where not the actual viscosity of the liquid is affected but the volume rate of flow of such a mixture through an orifice.

From an advance paper of the Institution of Mechanical Engineers is abstracted a discussion on the standardization of pipe flanges and flanged fittings, containing among other things data of an investigation as to the stresses on the flange, which the author proves to be of two kinds.

The pre-cooling of Canadian fruits and the general subject of fruit handling is discussed in a paper before the Ontario Fruit Growers' Association, where also are quoted some interesting results and a cold storage laboratory connected with a pre-cooling plant in Ontario, Canada.

The subject of forged and rolled steel pistons on locomotives is treated by W. W. Scott, Jr., in a paper before the Railway Club of Pittsburgh. The author takes up the matter from the point of view of locomotive balancing and gives some interesting data on the present tracks on the Pennsylvania lines, especially, and then proceeds to the description of a new method of manufacturing locomotive pistons, developed at the Homestead car wheel works of the Carnegie Steel Company.

Several papers are abstracted from the Journal of Mechanical Engineers, Tokio, Japan, such as the distribution of stress in a tension strap having a circular hole filled with a plug; the theory of elasticity of rods whose center line is a space curve and a paper on the transversal strength of wire guns.

From an extensive paper on the Coon Rapids hydro-electric development on the Mississippi River near Minneapolis by J. W. Links (Western Society of Engineers) data on some features of construction of interest to the mechanical engineer are reported.

## FOREIGN REVIEW

**Air Machinery**

PORTABLE AIR COMPRESSOR AND DYNAMO PLANT

The article is devoted to the description of the Kaiser Wilhelm bridge in Fürstenwald and among other things it describes a portable dynamo and compressor installation used in the construction of that bridge. Only the latter is abstracted here.

The portable dynamo and compressor plant shown in Fig. 1 consists of a 30 h. p. benzole engine *a* with two hand feed pumps, for benzole and water. The compressor *b* of 2.2 cbm. (77.68 cu. ft.) capacity with manometer, automatic cut-off, return cooling plant, water tank *c*, air tank *d*, 16 kw., direct current dynamo *e* working at 250 volts, and transmission pump *f*. All this is located on a powerfully built truck and weighs approximately 12 tons. It carries a main frame which both carries the load and serves as a water tank. This frame carries the benzole engine, compressor and dynamo. The dynamo and compressor are driven by the engine while the cooling water pump of the compressor is driven from the compressor itself. The hot water from the compressor is led to the roof of the car, distributed there and cooled, after which it returns to the water tank and continues the same circulation. The benzole engine circulating water is cooled by evaporation.

The entire plant may be carried or loaded in a car in a single unit and can be brought direct to the work for

which it is wanted. As soon as the proper tanks are filled with water and fuel, it is ready for operation. The engine is automatically regulated by the throttling of the fuel supply. The fuel consumption is approximately 300 grams (0.66 lb.) per h. p.-hr. and cooling water lost through exaporation is approximately 26 gal. per working day of 10 hr. (*Die Kaiser-Wilhelm Brücke in Fürstenwalde a. d. Spree,* Karl Bernhard, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, No. 3, p. 51, January 16, 1915, serial article, not finished, *d*).

### Turbo-Blower Governing Devices

The article describes steam turbines and turbo blowers exhibited at the Swiss National Exposition in Bern in 1914 by Brown, Boveri and Company. Only the part referring to regulating devices is here abstracted.

In blast furnace blowers, two kinds of regulation may be required. The more usual one, for constant output, can be brought about by means of the apparatus shown in Fig. 2 A. The governor drive is effected by means of oil pressure transmission from the turbine to a spring loaded piston *a,* actuating the main steam valve *b.* The steam admission is controlled by the centrifugal governor *c,* limiting the maximum speed of rotation, while the output is controlled by the auxiliary piston *d.* This latter is acted upon from below by the pressure in the blower pressure piping and from above by an apparatus *e* (known as the Rateau Multiplicator) which produces a pressure inversely proportional to the amount of air flowing through. The spring *f* contracts in proportion to the pressure difference and adjusts the regulating disc so that when the amount of air delivered becomes too great, the throttling valve is partly closed, which leads to the decrease in the speed of rotation of the turbine. If on the other hand, it is desired to have a constant pressure, a similar apparatus is used, but the multiplicator is eliminated so that above the piston *d,* the pressure is atmospheric.

One of the most important auxiliaries of a turbo blower governor is a device the purpose of which is to prevent "pumping." As used by Brown, Boveri and Company and shown in Fig. B, it consists of an automatic exhaust valve *e,* which at all times permits the escape of at least enough air from the pressure piping into the atmosphere or suction piping so that the amount of air taken in is at all times larger than that at which the blower could start "pumping." The regulating organ proper is the piston *a,* the lower part of which is at all times exposed to the dynamic or static pressure from the pressure piping while on the upper side, there is a partial vacuum produced either by means of the "multiplicator" or by simple throttling and is proportional to the amount of air delivered. Should the latter become too small, the piston goes down and through the small governor disc and permits at *e* the exit of the regulating compressed air, as a result of which the pressure of the latter below the piston *b* decreases (on account of the constant dimensions of the small exit at *f*). Thereafter, the spring *d* overcomes the opposition of the compressed air and opens the exhaust valve *e.* Since the par-

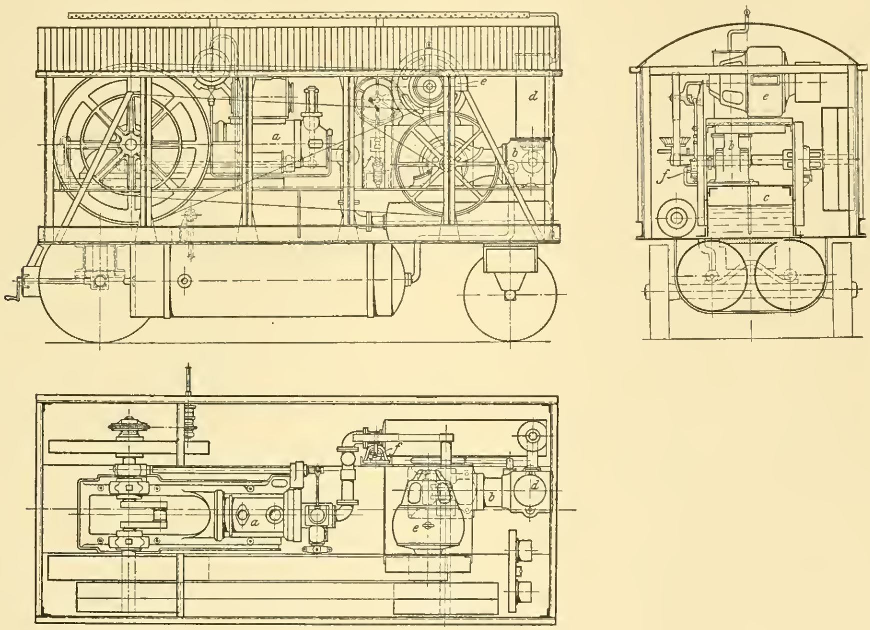
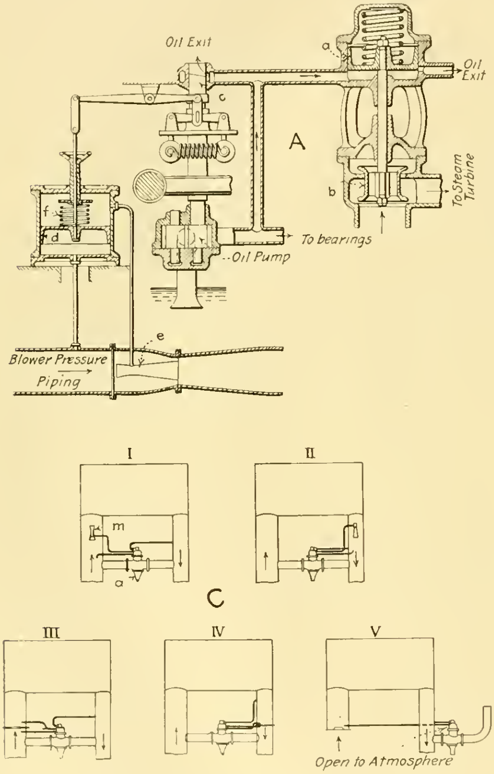


Fig. 1 Portable Air Compressor and Dynamo Plant

tial vacuum on the piston *a* is proportional to the amount of output, the stroke of the controlling valve, because of the presence of the spring *g*, will vary in the same sense, while the stroke of the exhaust valve will be approximately inversely proportional to the amount of air handled. In this way an arrangement can be made which would stop the efflux at a definite amount of air sharply above the "critical" limit. Fig. I to V in C show the various possible arrangements of the exhaust valve. (*Die Dampfturbinen und die Turbogebläse an der Schweiz. Landesaus-*



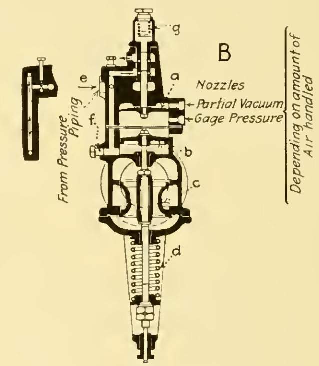




Fig. 2 Turbo-Blower Governing Devices

*stellung Bern* 1914, Professor A. Stodola, *Schweizersche Bauzeitung*, vol 65, No. 3, p. 24, January 16, 1915, serial article, not finished, *d*).

**Gas Producers**

Gasification of Rough Lignite.

The article describes a gas producer for rough lignite and tests of the same. The producer is of the Blezinger type previously described in The Journal (November 1913, p. 1692.).

Previous to charging, one of the two grate bars is heated up with a mixture of wood and lignite and carried under one of the empty gas producer shafts. The height of the fall of the coal is determined by the properties of the fuel used and may be varied by raising or lowering the hopper pipe in the shaft. The temperature in the zone of gasification is approximately 800 deg. cent. (1472 deg. fahr.) and this heat is used for the gasification of the coal and vaporization of the water. If the gas temperature is too high, the hopper is raised and the height of fall increases. If the gases are too cold, it shows that the height of the fall is too great and this is remedied by a corresponding lowering of the hopper pipe. At a temperature below 100 deg. cent. (212 deg. fahr.) the water originally contained in the lignite is found in the gas stream in the form of tiny bubbles rather than of steam.

The gas is cooled in a washer to a temperature of about 20 deg. cent. (68 deg. fahr.) which eliminates any water so that it reaches the place of combustion technically pure. At the same time, the major part of the tar is also taken out and may be used as a valuable fuel for driving Diesel engines, heating smelting furnaces, etc. By further processes of cleaning, for example by means of centrifugals, the lignite gas can be excellently adapted for use in gas engines. The gas producer itself requires practically no attendance during its operation as the admission of lignite is done mechanically and regulated automatically.

As shown in Table 1 most of the German lignites have been tested in these gas producers. When the gases were used in a Lancashire boiler the useful effect of over 80 per cent of the combustion zone—that is, in the front part of the fire tube was obtained with temperatures of 1200 to 1250 deg. cent. (2192 to 2282 deg. fahr. by a Wanner pyrometer) while the temperature of the flue gases was only 190 to 220 deg. cent. average (374 to 428 deg. fahr.). This shows that there was a fall in temperature across the boiler of about 1000 deg. cent. (1800 deg. fahr.).

There can be absolutely no deposit of impurities in the flues and with proper regulation of air admission the combustion is absolutely free from smoke or dust. The profit from the saving of tar, which is taken at 2 per cent. is quite sufficient to cover the wages of the help at the producer. The main advantage claimed for this type of producer, however, lies in the fact that it permits the gasification of lignites containing high percentages of water (as high as 45 to 60 per cent) which hitherto could only be

used to a very limited extent. (*Vergasung von Rohbraunkohle*, R. Klostermann, *Giesserei-Zeitung*, vol. II, no. 24, p. 633, December 15, 1914, 4 pp., 3 figs. *de.*)

### Mechanics

NOTCH SHOCK TESTS AND THE LAW OF SIMILARITY

The article reports experiments made in order to determine whether the law of similarity applies to notch shock tests.

The International Association for Testing Materials, at the Congress held in 1909 in Copenhagen, has accepted certain regulations for notch shock tests, such as the variation between the energy of blow and cross section of rupture, which the German Society for Testing Materials has called "specific energy of blow." The latter also adopted a small bar geometrically similar to the standard bar, but one-third the latter in all dimensions; that is, 1 cm. on the side of a square section, and the distance between supporting 40 mm. instead of 120 mm. It was expected that the proportional dimensions of both bars would permit the comparison of specific energies of blow and the Report of the Society in this connection calls attention to the experiments of Revillon which are claimed to have established the fact that when proportional bars were used, the specific energies of blow are equal.

The author for several years has held that the Revillon experiments were not conclusive and that considerations derived from the law of similarity would indicate that such an assumption ought not to be made without full tests. According to the law of similarity, one would expect that energies of blow would be related to each other as the cubes of the respective dimensions of bars and that therefore a bar one-third as large would require only 1/27 part of the energy consumed by the standard bar. On the other hand, the International specification assumes that the energies of blow would vary as the squares of the dimensions of the bars, or that the smaller bar would require only one-ninth of the energy necessitated by the larger bar. This discrepancy could be solved only experimentally and the second part of the article describes experiments made by the author for this purpose. (Fried. Krupp Co. of Germany defrayed the cost of these experiments.)

Charpy pendulum hammers having a capacity of 110, 75 and 10 kg—m. were used, after careful previous testing and with the resistance at no-load swinging of the hammer taken into consideration. For purposes of tests, bars were used of square section, 3 cm. and 1 cm. on each side of section, the diameter of the notch being 6 mm. and 2mm. The notches otherwise were entirely similar and reached down to the middle of the bar. The distances between supports were respectively 120 and 40 mm. Most of the bars used for the 1 cm test were made from the 3 cm bars of carbon steel, nickel, and chrome-nickel steel.

In all cases, it was found that to break the smaller bar a larger amount of energy was necessary than accorded with the law of proportionality. It was found also that the assumption of the International Association for Testing Materials made as a basis for test specification, viz. that the 3 cm and 1 cm proportional bars have the same values for the specific energy of blow is not even approximately correct, which might have been expected. What was less to be expected is that the energies of blow do not vary as the cubes of the dimensions of the bars and that the law of proportionality therefore is not applicable to notch shock tests. After it has been established that within the limits used in the experiments, the velocity of blow has no influence on the results and that there were no errors

TABLE 1 TEST OF A BLEZINGER GAS PRODUCER ON GERMAN ROUGH LIGNITES

| | | Composition of Coal, in per cent | | | | | | Heat value (lower) determined by calorimeter WE (conversion factor to B.t.u. per lb. — 1.8) | Composition of Gas, in per cent of volume | | | | | | | | | Cub. meters of gas per kg. of coal per cent | Efficiency of gas producer, per cent | Combustible material in ash, in per cent of fuel | Temperature of gas, deg. cent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C | H | O+N | S | Ash | Water | | $CO_2$ | $C_2H_2$ | O | H | $CH_2$ | CO | N | Combustible constituent | Lower heating value | | | | |
| | 1 | 36.63 | 3.19 | 15.19 | 0.22 | 8.37 | 36.40 | 3158 | 5.90 | 0.50 | 0.2 | 13.9 | 2.40 | 25.2 | 51.90 | 42.0 | 1410 | 1.995 | 89.06 | .. | 78 |
| | 2 | 25.17 | 2.12 | 12.10 | 0.41 | 7.85 | 52.35 | 1932 | 10.20 | .. | 0.1 | 6.9 | 3.50 | 22.7 | 56.60 | 33.1 | 1166 | 1.278 | 77.13 | .. | 78 |
| | 3 | 23.69 | 1.96 | 9.61 | 0.10 | 1.44 | 63.20 | 1793 | 8.70 | 0.30 | 0.3 | 11.2 | 1.00 | 18.6 | 59.90 | 31.7 | 988 | 1.538 | 84.75 | .. | 78 |
| | 4 | 29.29 | 2.22 | 9.13 | 1.19 | 6.71 | 51.46 | 2321 | 9.10 | 1.20 | 0.3 | 9.3 | 1.30 | 17.8 | 61.00 | 32.7 | 1160 | 1.842 | 82.25 | 31.78 | 80 |
| | 5 | 29.29 | 2.22 | 9.13 | 1.19 | 6.71 | 51.46 | 2321 | 7.70 | 1.00 | 0.6 | 9.8 | 2.20 | 20.1 | 58.60 | 31.3 | 1300 | 1.750 | 87.53 | 31.78 | 75 |
| Rough Lignites, | 6 | 28.60 | 2.80 | 11.80 | 0.40 | 6.40 | 50.00 | 2412 | 7.86 | 1.40 | 1.0 | 9.2 | 1.70 | 17.3 | 61.50 | 29.6 | 1141 | 1.868 | 88.36 | .. | 89 |
| German | 7 | 29.30 | 2.15 | 11.83 | 0.24 | 3.92 | 52.48 | 2310 | 8.00 | 1.00 | .. | 10.6 | 2.10 | 19.8 | 58.50 | 33.5 | 1219 | 1.763 | 85.37 | 41.00 | 78 |
| | 8 | 33.46 | 2.81 | 10.15 | 0.92 | 9.76 | 42.90 | 2972 | 7.20 | 0.80 | .. | 11.9 | 1.60 | 20.0 | 58.50 | 34.3 | 1182 | 2.091 | 83.16 | .. | 72 |
| | 9 | 23.62 | 1.79 | 10.18 | 0.18 | 2.72 | 61.51 | 1833 | 8.90 | 0.85 | .. | 12.7 | 1.44 | 19.5 | 56.61 | 34.5 | 1185 | 1.423 | 91.90 | .. | 83 |
| | 10 | 26.70 | 1.80 | 11.01 | 0.12 | 1.44 | 58.93 | 1973 | 9.40 | 0.20 | 0.3 | 11.3 | 1.50 | 15.1 | 62.20 | 28.1 | 912 | 1.880 | 86.87 | .. | 73 |
| | 11 | 34.90 | 2.86 | 10.48 | 0.58 | 5.86 | 45.32 | 3050 | 7.40 | 0.30 | 0.1 | 10.9 | 0.10 | 20.6 | 60.60 | 31.9 | 963 | 2.281 | 72.03 | .. | 78 |
| | 12 | 31.90 | 2.88 | 9.59 | 0.88 | 7.78 | 46.97 | 2787 | 7.50 | 1.10 | .. | 10.7 | 1.30 | 22.1 | 57.30 | 35.2 | 1239 | 1.846 | 82.07 | .. | 75 |
| | 13 | 31.90 | 2.88 | 9.59 | 0.88 | 7.78 | 46.97 | 2787 | 7.20 | 0.70 | .. | 9.8 | 1.70 | 21.4 | 59.20 | 33.6 | 1163 | 1.903 | 79.42 | .. | 73 |
| | 1 | 53.57 | 4.49 | 14.53 | 1.70 | 9.63 | 16.17 | 4908 | 4.90 | 0.10 | .. | 9.8 | 2.20 | 29.0 | 54.00 | 41.1 | 1424 | 2.733 | 79.30 | .. | 270 |
| | 2 | 52.64 | 4.07 | 13.68 | 1.15 | 9.04 | 19.42 | 4752 | 7.60 | 0.80 | .. | 12.1 | 2.70 | 21.6 | 55.20 | 37.2 | 1332 | 2.974 | 83.36 | .. | 292 |
| Briquettes from | 3 | 47.70 | 3.85 | 14.84 | 1.13 | 12.64 | 19.84 | 4498 | 4.60 | 0.80 | .. | 15.9 | 2.80 | 22.7 | 53.20 | 42.2 | 1470 | 2.856 | 85.21 | .. | 300 |
| German Lignites | 4 | 51.26 | 2.96 | 20.16 | 0.26 | 7.83 | 17.53 | 4531 | 3.60 | 0.20 | 0.1 | 12.3 | 3.60 | 28.9 | 51.30 | 44.8 | 1534 | 2.841 | 85.75 | .. | 450 |
| | 5 | 62.47 | 3.79 | 8.73 | 3.20 | 16.74 | 5.07 | 5928 | 4.00 | .. | .. | 10.4 | 4.10 | 23.2 | 58.30 | 37.3 | 1522 | 3.396 | 84.77 | .. | 410 |

of observation which might account for this fact, one can only ascribe it to the fact that the assumption concerning the law of similarity has not been satisfied in the test bars. This assumption is the *similarity of structures:* apparently, instead of having in the two cases proportional structures, there were similar structures. This is explained in the following manner: both the larger and smaller test bars, made of such crystalline materials as steel, consisted of grains of approximately equal size.

If, however, the rupture occurs along the lines of the crystalline formation, one can easily see that in regard to the rupture in bars otherwise proportional to each other, there exists not a proportionality but an equality. This is because when the rupture occurs along the faces of crystallization, it occurs really along the surfaces of the least resistance, and one may just as well assume that the crystalline grains are divided from one another by comparatively thin layers of material of little resistance. This will be clearer if we assume that these thin layers are located

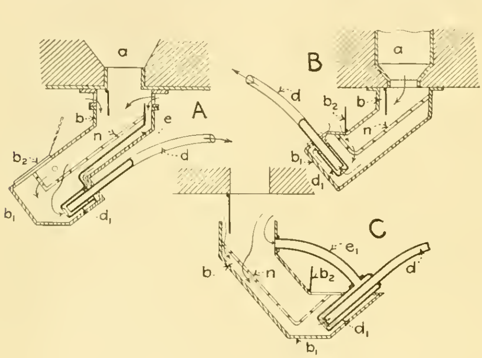



Fig. 3 Devices for Removing by Suction Ashes and Slags

parallel to the plane determined by the notch and direction of blow. In that case, the proportional bars would consist of thinner and thicker layers of very low mechanical resistance and, although the dimensions of the bars may be different, the thickness of the respective layers would be the same. Let it be assumed further that the central plane of the notch falls in the middle of the thin divided layer and that the notch of the larger bar does not reach the limits on both sides of the thin layer of divided material. If the permanent deformation which occurs at the blow, extends only to the layers of low resistance located in the plane of the notch, the volume of which is proportional to the square of the dimensions of the bars, one cannot expect that the energy of blow will be proportional to the *cube* of the respective dimensions.

The most characteristic element of the example, the fact that the thickness of the layer undergoing deformation is independent of the ratio of dimensions, is especially evident in the case of brittle materials. In the case of tough materials, the variation between the thickness of the volume subject to change of shape is approximately proportional to the dimensions of the bars. Accordingly, the ratio of specific energies of blow in the case of bars of proportional dimensions is variable, and is unity for fragile materials. For tough materials, it varies approximately as the dimensions of the bars. It appears, therefore, that no general rule can be established and that at any rate, the law of similarity is not generally applicable to this case. (*Die Kerbschlagprobe und das Aehnlichkeitsgesetz,* R. Stribeck, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, No. 3, p. 57, January 16, 1915, 4 pp., *et*).

**Steam Engineering**

### Dust-Free Suction of Ashes and Slags

The article describes devices for removing by suction ashes, slags, etc. from a grate without permitting dust and hot gases to escape into the outside atmosphere.

Wherever the ash removal by suction is effected by the use of a completely closed chamber, the admission of fresh air from the outside is effected by a separate admission nozzle. There are, however, a good many cases in which an absolute exclusion of air all along the path of the ashes is for various reasons, impossible, and in this case one has to reckon with the serious disadvantage of having dust and hot gases escape on all sides. The device described in this article is claimed to eliminate this disadvantage by taking in the air for the working of the apparatus at the very places through which the dust and gases would otherwise escape.

Three designs of this apparatus are described and illustrated in the article. In the first one, a suction chamber $b$ is assumed to be entirely open on top, which corresponds to a condition in which no airtight closing of the top is possible. The suction chamber $b$ is shaped downward somewhat like a sack, the upper part $b$ being separated from the lower part $b^1$ by a grate $n$. It is of advantage to place this grate in an inclined position and to arrange it in such a manner that it would force all the ash and slag to move toward the suction nozzle in order that the latter may have a chance to break up too large pieces of slag. This is the reason why the door $b_2$ is provided, giving admission both to the grate and to the tip of the suction nozzle $d_1$. When $b_2$ is closed, all the air required to force the material through the delivery pipe $d$ is taken from above and it is impossible therefore that dust or gases should escape that way.

When larger amounts of slag or ashes drop in suddenly however, or other disturbances take place, it may happen that material would heap up on the grate, and care must be taken therefore to admit sufficient air to the suction nozzle tip $d_1$ to handle this excess of material. For this purpose, under the grate, a special passage $e$ is provided which is always open on top and which admits the air taken from above through the nozzle tip $d_1$ to the suction pipe $d$, as shown by arrows in the drawing. In this case also, the fact that the air is taken in from above prevents the dust from escaping that way. But even when (in order to eliminate such disturbances as may occur) $b_2$ is left open, the admission of air for operating the suction device still remains sufficiently large to prevent the exit of dust at that place while the air is being sucked in through it.

In the second design shown in Fig. B, the suction chamber $b$ is rigidly connected with the ash exit $a$. The material falls on the inclined grate $n$ where exceptionally large pieces are broken up in this case also by the door $b_2$. The air admission to the suction nozzle $d_1$ occurs through an

opening in $b_2$ which remains entirely open, and the air is permitted to flow both through the grate and underneath it in a manner indicated by the arrows, so that in this case, even with an open damper $b_2$, the dust cannot escape.

Finally, in the third design, Fig. C, the chamber $b$ is again assumed to be open on top. Ash and slag fall on the grate $n$ and the suction air is again taken from above, but in this case the air is admitted to the suction nozzle $d_1$ through the damper $b_2$ and in addition to that an intermediary pipe $e_1$ is provided, connecting the upper part of the suction chamber $b$ with the nozzle pipe $d$, thus admitting fresh air to the latter as required. (*Staubfreie Absaugung der Asche, Flugasche, Schlacke usw. aus den Asche kammern bei Verbrennungsanlagen aller Art, bei welchen das Gut durch einen Rost tritt*, Fritz Hartmann. *Rauch und Staub*, vol. 5, No. 1, p. 7, October 1914, 2 pp., 3 figs. *d.*)

### Relation Between Quality of Steam and Load on the Boiler in the Case of a Cornish Boiler

The article reports test data on investigation showing the relation between wetness of steam and load on the boiler, in the case of Cornish boilers.

The tests were carried out in the experimental laboratory of the Bavarian Association for Boiler Inspection. The boiler has a longitudinal corrugated flue (Fig. 5 A), located off the center line. The boiler was put up in 1903 by the Augsburg-Nuremberg Machine factory for 13 atmospheres gage pressure. Its main dimensions are indicated in millimeters on the figure. After the hot gases leave the flue, they pass forward along the right side of the boiler, then back along the left side of the boiler, and finally escape through the smoke stack, 40 m (131 ft.) high and 0.7 m (27.5 in.) diameter of top opening. During the test, the superheater which belonged to the boiler, was separated from the fire tubes by a wall. The feed water was supplied by a duplex steam pump through a simple pipe introduced in the middle of the last section of the shell and the steam was taken out through a dome. In addition to the steam taken for the quality test, a certain amount of it was also delivered to the pump. The steam to be tested left the dome through a quarter bend directed upwards, traveled through an angular valve, then into a throttling calorimeter in the same manner as was used previously by the same laboratory for the water tube tests, and was finally exhausted into the atmosphere through a long pipe crossing the boiler room and the engine room.

On the Cornish boiler, eight tests were made with the throttling calorimeter the results of which are in the main given in Table 2. Fig. B shows the functional relations between the amount of steam produced per sq. m. of boiler heating surface and the total amount of moisture in front of the throttling valve. In order to be able to compare data previously obtained on water tube boilers with those of the Cornish boiler, the curve for the total moisture of the water tube boiler was also plotted. The figure shows that in the case of the Cornish boiler as well as in that of the water tube boiler, the moisture in the steam decreases with the increase of load, but the comparison of the two curves shows that the water tube boiler produces steam of greater moisture than the Cornish boiler and the percentage of moisture in the latter boilers is less than in the former.

*Die Abhängigkeit der Dampffeuchtigkeit von der Kesselbelastung bei einem Einflammrohrkessel, Zeits, des Bayerischen Revisions-Vereins*, vol 18, No. 22, p. 203, November 30, 1914, 3 pp., 2 figs. *e*).

### German Progress in Steam Boiler Firing

Description of various new inventions in the field of steam boiler firing, patented in the last quarter.

H. Brams patented in Germany (No. 278513) a grate with automatic stoking and cleaning, provided with longitudinally located grate bars. As shown in Fig. 4 A, it consists of an internal rotatable pipe and other pipes externally and helically wound around it. The movement of this pipe can occur in such a manner that the internal pipe may either rotate or remain stationary while the external spiral pipes rotate either in the same or in opposite direction. This arrangement, in which the inner pipe rotates one way and the outer pipes rotate in the opposite direction, is claimed to be most appropriate for all kinds of fuels and is also very simple. One or more of the helically wound pipes $b$ around the straight line pipe $a$ of the grate bar help to move the fuel forward to the fire bridge. The cooling liquid flows through the water chamber $q$ located crosswise across the entire width of the grate, the ends of the pipe $a$ being screwed into the chamber through the stuffing boxes $h$. At $r$ the pipes have openings located circumferentially, through which the liquid can flow into a rotatable hollow element $c$, placed about the pipe $a$. At $e$ and $g$, the hollow element is rotatably fixed with proper packing about the inner tube. The ends of the helical pipes $b$, distributed symmetrically around the circumference, open (water-tight) into this hollow element $c$.

The drive of the grate is through worms $o$ and $p$ and is regulated in accordance with the speed of the fuel delivery on the grate. The internal pipe carries wheels $k$ which are in engagement with the worm $p$ while the hollow element $c$

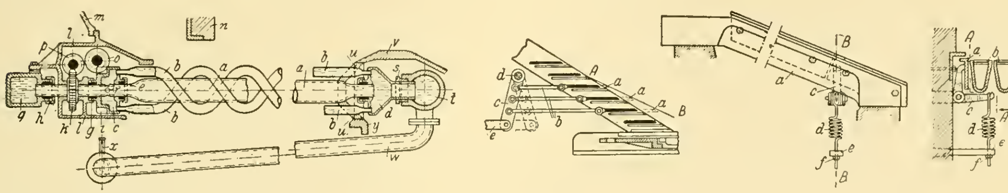
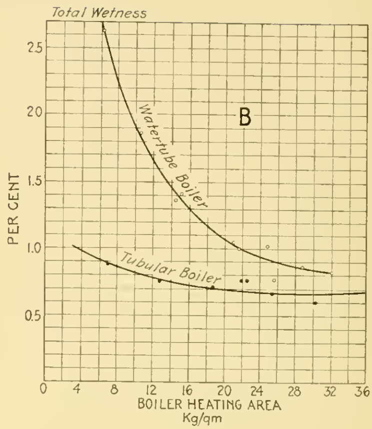


FIG. 4 RECENT TYPES OF BOILER FURNACE GRATES

is provided with a toothed wheel $i$ in engagement with the worm $o$. The whole drive is located near the gear box $l$ and the regulation of the hopper delivery is effected through the hopper door $n$. At the fire bridge end of the grate, the pipes $a$ open into a rotatable hollow body $d$ into which also open the external pipes, through water-tight joints. All the hollow bodies are connected through stuffing boxes $s$ with the collector pipe $t$ from which the cooling water is taken by the pipes $w$. At that point the temperature of water is read by a thermometer $x$. A regulating valve permits the control of velocity of flow of cooling water through the grate in such a manner that there is no scale deposit in the grate elements. In order that clinkers may not get into the packing and stuffing boxes, rotating elements $u$ are provided and placed rotatably to the plane of the fire bridge so as to deflect them in falling.

In regard to inclined grates, the invention of F. Albrecht, (German patent No. 276,548) is somewhat of a novelty.



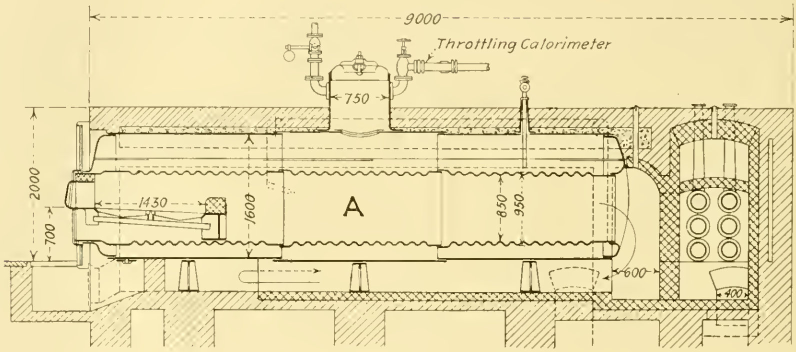




Fig. 5 Plant used for Testing the Relation between Load on Boiler and Wetness of Steam, and Curves showing Results Obtained

TABLE 2 RELATION BETWEEN QUALITY OF STEAM AND LOAD ON BOILER WITH CORNISH BOILERS

| No. of Test | Feedwater consumption per hr., kg./conv. fact. to lb.—2.2 | Water of condensation from steam pump, kg./conv. fact. to lb.—2.2 | Steam per hr. in front of the throttling disc, kg./conv. fact. to lb.—2.2 | Water of condensation, per hr., in front of the throttling disc, less loss in metering device, kg./conv. fact. to lb.—2.2 | Gross wetness, per cent | Bore of the throttling disc, mm./conv. fact. to in.—0.039 | In front of throttling disc: Absolute steam pressure, atmospheres | In front of throttling disc: Corresponding temperature of saturated steam, deg. cent. | In front of throttling disc: Temperature as indicated by thermocouple, deg. cent. | Absolute steam pressure, atmospheres | Corresponding temperature of saturated steam, deg. cent. | Temperature of cold soldered joint, deg. cent. | Behind throttling disc, Thermoelements I | II | III | IV | Average steam temperature, deg. cent. | Superheat, deg. cent. | Quality (without regard to velocity), per cent. | Quality (velocity considered), per cent. | Total wetness of steam in front of throttle, per cent. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 279 | 37 | 242 | 0.50 | 0.21 | 8 | 11.1 | 183.5 | 184.3 | 1.7 | 114.5 | 29.0 | 152.0 | 150.1 | .. | 151.7 | 151.3 | 36.8 | 0.68 | 0.67 | 0.88 |
| 3 | 512 | 38 | 474 | 0.57 | 0.12 | 11 | 11.2 | 183.9 | 185.0 | 3.2 | 134.9 | 32.3 | 157.1 | 157.4 | 155.5 | 157.8 | 156.9 | 22.0 | 0.64 | 0.63 | 0.75 |
| 4 | 750 | 47 | 703 | 0.25 | 0.04 | 14 | 11.4 | 184.6 | 185.4 | 1.7 | 114.5 | 27.8 | 150.2 | 152.1 | 151.4 | 150.3 | 151.0 | 36.5 | 0.76 | 0.68 | 0.71 |
| 5* | 903 | 51 | 852 | ... | .. | 15 | 11.4 | 184.6 | 184.5 | 1.9 | 118.0 | 25.8 | 149.4 | 152.2 | 151.7 | 150.4 | 150.9 | 32.9 | 0.86 | 0.76 | 0.76 |
| 7* | 881 | 53 | 828 | 0.12 | 0.01 | 15 | 11.1 | 183.5 | 183.2 | 1.8 | 116.3 | 28.7 | 149.5 | 149.1 | 151.5 | 149.9 | 150.0 | 33.7 | 0.85 | 0.75 | 0.76 |
| 6 | 1018 | 55 | 963 | 0.03 | 0.00 | 16 | 11.0 | 183.1 | 183.3 | 2.1 | 121.0 | 27.7 | 150.9 | 152.5 | 152.5 | 151.1 | 151.8 | 30.8 | 0.76 | 0.66 | 0.66 |
| 8 | 1210 | 64 | 1146 | 0.16 | 0.01 | 17 | 11.0 | 183.1 | 183.4 | 2.3 | 123.7 | 29.6 | 152.6 | 152.0 | 153.8 | 152.6 | 152.8 | 29.1 | 0.71 | 0.59 | 0.60 |
| 9 | 1430 | 71 | 1359 | 0.13 | 0.01 | 19 | 11.1 | 183.5 | 182.0 | 2.6 | 127.9 | 26.8 | 153.0 | 153.0 | 154.6 | 153.0 | 153.4 | 25.5 | 0.79 | 0.66 | 0.67 |

* Comparison of No. 7 to No. 5

Each grate bar consists of a frame the two parts of which are connected by a cross-piece. In this frame, stepped plates can be inserted and held on the side away from the fire. It is important to notice that the frame itself is open from behind and this permits of shoving the stepped plates quite far into the frame. In actual practice, it was found that to afford the plates an opportunity to cool they must be made so their depth is greater than their width.

Ph. Werger, who has previously patented an inclined step grate system of firing with hollow grate bars movable longitudinally, has now introduced a further improvement (German patent No. 277,330) which consists in the fact that the cheeks of the grate can be pressed against the grate bars by an angle lever which may be operated from outside either by a spring or by a weight. Fig. C and D show one design of this new type. The movable cheeks *a* which do not take part in the longitudinal motion of the other grate bars *b*, are pressed against them by the angle lever *c*. The horizontal arm of this lever located under the grate, is operated by means of a helical spring *e*, rigidly fixed on the fire wall in such a manner that the tension of that spring and therefore the pressure of the bar *a* against the grate bars *b*, could be adjusted as desired. (*Neue Patente auf dem Gebiet der Dampfkesselfeuerung*, Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 38, No. 4, p. 27, January 22, 1915, serial article, not finished, *d*).

## ENGINEERING SOCIETIES

### AMERICAN INSTITUTE OF MINING ENGINEERS

*No. 97, January 1915.*



Coal-Dust Fired Reverberatory Furnaces of Canadian Copper Co., David H. Browne.

The paper describes coal-dust fired reverberatory furnaces, taking up also to a certain extent the history of the use of coal-dust for metallurgical purposes in Northern America. In the early part of the development, about 1909, it was found that at Highland Boy and Cananea, there were two mechanical difficulties encountered, stoppage of flues with the accumulation of ash, and interruptions and irregularities in the coal-dust feed. At the same time, the practice of cement plants demonstrated that the operations of feeding and burning pulverized coal could be made quite continuous, uniform, and well regulated provided that the proper methods were used in the preparation of the coal.

In the new plant means were provided both for preventing possible accidents and for regular operation of the plant. Especial care was taken to specify that all bins, conveyors, etc., for the pulverized coal should be made as nearly dust-proof as possible by the use of rubber gaskets to eliminate the danger of dust explosions. Further, to obviate the possibility of trouble from the accumulation of coal ash, an entirely new arrangement of the furnace flue was designed to provide a straight-away course for the gases. In doing this, the skimming door was taken from its traditional position at the end of the furnace and placed on the side without entailing thereby any material sacrifice. As built, the original furnaces were lined with basic brick and the hearth was an inverted arch of magnesite.

The furnaces went into operation before any proper means of drying coal dust were provided and during the winter of 1911-12 a large amount of the charge, wet and frozen as it came from the piles, was shoveled in through the doors of the furnace. All the converter slag was poured in at first through an opening in the roof and later by means of an iron chute through a door near the fire end. The introduction of so much cold air and cold material prevented any satisfactory fuel ratio which at first was 6.7 tons of total charge per ton of coal but only 2.2 tons of cold charge per ton of coal. The combustion of the fuel, however, was satisfactory from the start, no trouble being experienced either in grinding or burning the coal. The ash, while working on cold charges, choked and clogged the flue at the throat and this difficulty was not eliminated until hot calcine was used and a larger tonnage was smelted. In general, the slower the furnace is working the cooler is the ash and the more it sticks and accumulates, while the faster the furnace is driven the less does the ash hang back in the furnace, and with rapid smelting it becomes a negligible factor.

During the following years, improvements in the construction of the furnaces were made. Long and shallow pockets were provided along the side walls, and through holes in the roof green ore fines were fed to protect the sides. This led to the bricking up of the doors of the furnace and the marked improvement which resulted from the exclusion of cold air and the insulation of the walls by a non-conducting and continuously renewed blanket of fines brought about the extension of this side fettling system to take in almost the entire charge of calcines. Further, as the walls were thoroughly protected by the charge, the use of basic brick in the walls and hearth was no longer necessary and it was changed to the siliceous bottom and the customary siliceous brick walls. The fuel ratio also improved very materially.

The article describes in detail the construction of the furnace. The coal-dust is introduced through five pipes 5 in. in diameter. One of these pipes is on the center line of the furnace; the others are in horizontal line with it at a distance of 3 ft. 3 in. from center to center. The coal used in firing is a good quality of slack, a thermal value of about 13,500 B. t. u. per lb., is about $^3/_4$ in. and under in size and contains about 7 per cent moisture. It is dried in a Ruggles-Coles dryer, 70 in. in diameter and 35 ft. long, and is then ground in Raymond impact mills so that about 95 per cent passes a 100 mesh and 80 per cent passes a 200 mesh screen. Any coal delivery pipe can be closed off by a slide gate and any screw conveyor can be stopped by disconnecting the beveled gears attached thereto. In this way any desired number of the five burners can be run and at any desired rate within wide limits.

The amount of air delivered to each nozzle can be varied at will or cut off entirely. As a rule all five burners are in operation, each delivering 13.5 tons of coal-dust a day. The air is supplied by a 4 ft. Sturtevant fan running at about 1300 to 1400 r. p. m. The air supplied by this fan is insuffi-

cient for the combustion of the fuel, and openings are left in the end wall between the coal burners, which are stopped by loose bricks so that the amount of air is readily controlled. (12 pp., 2 figs. *d*).

Coal-Dust Fired Reverberatories at Washoe Reduction Works, Louis V. Bender.

Description of coal-dust-fired reverberatories and results obtained therefrom.

The reverberatories at Washoe Reduction Works described in this paper have been made after an investigation of the Canadian Copper Company plant described in the preceding abstract. The coal from the storage bin is delivered to a 30 in. x 30 in. Jeffrey single roll coal crusher where it is reduced to 1 in. maximum size. It is then taken up by a belt conveyor to the foot of an elevator, passing over a Ding magnetic pulley which removes any pieces of iron, bolts, etc., and elevated and fed by gravity into a 40 ft. x 6 ft. 8 in. Ruggles-Coles drier. From here, the coal is lifted by a screw conveyor and discharged into a steel bin placed above the pulverizer, which is in a separate building from the drier. A Raymond five-roller mill is used with an average hourly capacity of 4.5 tons. To this mill is connected a fan from which air is admitted underneath the grinding surface, the material being taken away by the air current as quickly as it is reduced by the rolls and blown into a Cyclone dust collector placed 20 ft. above the pulverizer. The finished product is discharged through a spout

TABLE 3 COMPARISON BETWEEN FURNACES USING COAL ON GRATES AND COAL DUST

| Furnace | Tons Smelted per Furnace Day | Total Tons Smelted | Tons Coal | Fuel Ratio | | |
|---|---|---|---|---|---|---|
| | | | | | Excluding Drier Coal | Including Drier Coal |
| No. 7 | 250.96 | 7260.31 | 1870.94 | 3.88 | .... | .... |
| No. 8 | 475.75 | 14272.52 | 1984.77 | .... | 7 19 | 7 08 |

at the bottom of the dust collector and is taken up by a screw conveyor to a bin placed near and above the furnace.

The method of introducing the coal from the bin into the furnace is similar to that used at the Canadian plant. The amount of coal fed is determined by the speed of the screw which is easily regulated by a Reeves variable speed regulator. The entire grinding, conveying and bin system, from the driers to the burners is air tight so far as practicable, with the result that the entire plant is extremely clean and free from dust. The ash gives very little trouble. The article contains data on the coal used and the results obtained. As to the latter, a table showing the comparison between the working of two reverberatory furnaces, one using coal grate firing and the other the coal dust firing; is given in Table 3. (9 pp. 2 figs. *d.*)

Experiments on the Flow of Sand and Water through Spigots, R. H. Richards and Boyd Dudley.

The article describes experiments on the flow of sand and water through spigots, performed in the ore dressing laboratory of the Massachusetts Institute of Technology, for the purpose of securing data as to the relation between composition and viscosity of mixtures of sand and water. The problem to be solved particularly, as it is often encountered, belongs to the following class:

*With a given quantity of solids per unit time, of a given specific gravity, to be discharged with water under a given head, and with a given ratio of water to solid, what must be the size of the spigot opening?*

One of the factors affecting the solution of the problem is the viscosity of the material to be discharged and in this case the term "viscosity" has a somewhat special meaning in that it denotes the ratio of the volume of pure water that will flow through a given orifice under a given head in a given time, to the volume of the material under consideration that will flow through the same orifice in the same time under the same conditions. While the actual viscosity of water containing sand in suspension is not increased by the presence of the sand, still the volume rate at which the mixture will flow through an orifice is less

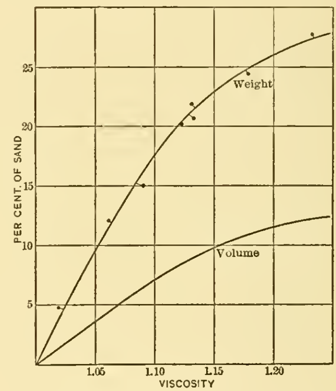



Fig. 6 Curves showing Relationship between Composition and "Viscosity" of Mixtures of Sand and Water

than that at which pure water will flow by reason of the friction of the particles of sand against each other and against the sides of the orifice. In other words, the flow is retarded as it would be by increased viscosity. Generally the area of the spigot opening can be calculated from the equation.

$$a = \frac{fq}{c\sqrt{2gh}}$$

in which $a$ is the area of the spigot opening; $f$ the viscosity of the mixture; $q$ the rate of discharge by volume; $c$ the coefficient of discharge; $g$, acceleration due to gravity and $h$ the head of water above the spigot.

The apparatus used in the test and shown diagrammatically in the article, consisted of a cylindrical tank of galvanized iron, having a conical bottom to which the spigot was attached and a mechanical feeder for delivering dry sand to the tank. By feeding enough water into it to supply the spigot in order to maintain a slight overflow, a constant head of water was maintained above the spigot. Below the tank a swinging sheet iron launder furnished the means of deflecting the spiot discharge into a bucket

for any desired time and this determined the rate of flow. The method used in conducting the test was as follows:

The tank was filled with water and the rate of influx conveniently adjusted. The feeder was then started and sand was delivered to the tank. The sand settled through the water and passed out of the spigot, thus increasing the amount of overflow not only on account of the added volume of sand but also because of the increased rate of discharge due to the passage of the sand through the spigot. When the sand and water mixture had been running from the spigot for a minute or two and the flow had become steady, the spigot discharge was deflected into the bucket for a measured length of time, usually for about 2 min. The feeder was then stopped, adjusted to deliver sand at a different rate and another test was made. The results of the experiment are shown in a table where the rates of flow are expressed in kilograms and liters per minute, while the relationship between the composition and viscosity of the mixtures is shown graphically in Fig. 6, where the ordinates of the upper curve are the percentages of the sand by weight, while those of the lower curve are the percentages of sand by volume with the viscosity of the mixture plotted as abscissæ in each case.

These tests have shown that when the amount of sand in the mixture exceeded 30 per cent by weight, the spigot would produce a very thick discharge for a short time but its continuous operation was not certain and clogging resulted sooner or later, so that the mixture of sand and water could not be sucessfully discharged from a spigot when the mixture contained more than about 30 per cent. of sand by weight (which for the sand used in these experiments corresponds to about 13 per cent of sand by volume). The following example, illustrating the use of the data given above, shows the practical value of this information. It was desired to discharge from the pocket of a classifier 40 tons of sand per 24 hr. together with water in the ratio of 1 part of sand to 3 parts of water by weight. The head of water above the spigot is 3 ft. and the form of the spigot is that of a short tube with a conical mouth at the influx end. The mean specific gravity of the sand is 2.81. What must be the diameter of the spigot opening?

The author goes through a complete calculation using the lower curve of the Fig. 6 for the determination of viscosity of the mixture, i e. $f$ in the equation on page 188, and thus determines the diameter of the spigot opening.

## INSTITUTION OF MECHANICAL ENGINEERS

*Advance paper D, read January 22, 1915*

Standardization of Pipe Flanges and Flanged Fittings, John Dewrance.

On April 18, 1902, Mr. Robert E Atkinson read before the Institution of Mechanical Engineers, a paper on the standardization of pipe flanges and of flanged fittings. As a result of it and the discussion to which it gave rise, the matter was, in the following year, taken up by the Engineering Standards Committee which appointed a Sectional Committee on Pipe Flanges to deal with the question. This committee included representatives of the Admiralty, various engineering associations and societies, and important manufacturing firms. After having held about thirty meetings, they presented a report (British Standard Tables of Pipe Flanges No. 10, November 1904) in which the flanges are standardized into four classes according to the pressure. The report also gives standard dimensions for the short bends and tees of cast metal and for long bends of wrought iron and steel. Some of the points concerning these standards are of interest.

The diameters of flanges and bolt hole circles are uniform for flanges intended for steam pressures ranging from 55 lb. to 325 lb. per sq. in., slightly smaller flanges being given for pressures up to 55 lb. per sq. in.

One of the points which caused a great deal of discussion was whether or not the number of bolts employed should be a multiple of 4 in all cases. Hydraulic press cylinders and heads are often connected by two bolts and seldom by more than four. Cast iron pipes up to 7 in. bore for

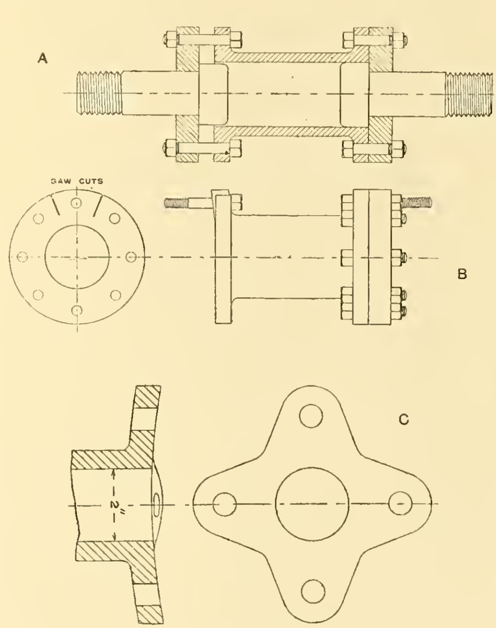



Fig. 7 Stresses in Pipe Flanges

hydraulic power up to 1200 lb. pressure per sq. in. are made with two bolts, but the reason why in English practice. only two bolts are used in the ends of hydraulic mains is that several pipes are laid side by side in the streets in branches and in order to be able to run the pipes in any direction standard tee bends and valves must be made in three variations,—one with the flanges vertical, another with the flanges horizontal and still a third with one flange vertical and the other horizontal. This led the sub-committee to the conclusion that there can practically be no standard at all unless the number of bolts used are multiples of 4. While four bolts would be sufficient for even the largest steam pipe flanges, the use of four bolts only in the larger

sizes would involve setting the bolt bracket on the flange back which is done in the hydraulic pipe flanges. This would require longer bolts which again would have to be much larger to stand the strain and would entail a greater cost than the use of the number of smaller bolts that was adopted. The clearance of 1/16 in. in the bolt holes for ½ in. and ⅝ in. bolts and of ⅛ in. for larger sizes was in the opinion of the sub-committee the smallest allowance that was practicable for commercial manufacture.

They did not agree to any formula as to the thickness of flanges that could be accepted for general use. The author's view is that two separate stresses have to be considered. The first is the stress necessary to distort the flange and the pipe considered as a cantilever; and the second is the stress necessary to cup the flange itself. To demonstrate this, a short piece of 2½ in. bronze pipe with two of the standard flanges, 7¼ in. in diameter and 1/16 in. thick, was made and drilled with eight holes to the British Standard (Fig. 7 A). One of the flanges was bolted up to a cast iron flange and the other flange was connected by bolts to another thick cast iron flange, leaving space between the bronze and cast iron flanges as shown in the figure. The cast iron flanges were then pulled apart in testing machines. At 17.28 tons, the last mentioned bronze flange set 1/32 in. and at 19.2 tons had a set of over ⅛ in.

Two radial saw cuts were then made in the flange, so as to bisect the distances between one of the bolt holes and the holes on either side of it, from the outside circumference of the flange to the barrel of the pipe. In this way, a one-eighth part of the flange was isolated from the rest. A bolt was passed through the hole in this isolated portion and another through the hole in the complete flange and the cantilever strength of the smaller was tested between the centers of a testing machine in the ordinary way as shown in Fig. B. A set of ⅛ in. was obtained with a load of 1.27 tons. This experiment proved that the flange owes 1.27 tons for each section of an eight, or 10.16 tons in all, to the cantilever strength and the balance of 19.2 or 9.04 tons to the strength of the flange itself.

A flange 6½ in. in diameter for 2 in. pipe and having four bolts was then taken and pulled in a similar manner. At 14.3 tons, there was a permanent set of 1/32 in. and at 16.99 tons a permanent set of ⅛ in. set. An exactly similar flange was then reduced to the shape shown in Fig. C. At 13 tons there was a permanent set of 1/64 in. and at 15.27 tons, a permanent set of ⅛ in.

This result is of great interest as it shows that formulae based on the strength of the girder between the bolts are not correct and also shows that there is an ample margin of strength when four bolts are used on a 2 in. flange. It also suggests that when it is necessary to keep the weight down as low as possible, the flange need not be round but may be a shape similar to that shown with four bolts in Fig. C, or a corresponding shape with eight bolts.

The thickness of the flanges embodied in the Standard Tables were arrived at by the sub-committee as the result of actual experiments by them. The British Standard Tables state the thicknesses for steel or wrought iron flanges welded on, the same as for cast iron flanges, notwithstanding the much greater strength of flange material in the former case.

The sub-Committee did not make any recommendations as to packings. The author states that the British Standard for pipe flanges is certainly the most largely adopted at the present time and recommends its adoption by those parts of the United States which have not already done so. (8 pp., 5 figs. *g*).

### ONTARIO FRUIT GROWERS' ASSOCIATION

(*Published in Cold, vol. 6, no. 4, February 1915, Calcium, N. Y.*), *Edwin Smith.*

PRE-COOLING OF CANADIAN FRUITS

Discussion of pre-cooling of fruit in Canada with some historical data concerning the products of pre-cooling. Description of the pre-cooling plant at Grimsby, Ontario.

In designing the Grimsby plant, the type selected was of the warehouse design. Ice is used as a refrigerating medium in a Cooper Gravity Brine system. The fruit is loaded and packed as soon as picked from the trees on specially designed trucks which are then run into one of the four pre-cooling rooms. Each room holds more than a carload of boxes or baskets loaded on trucks and has a perforated floor and ceiling through which a circulation of cold air is blown from the coil room by means of large 60 in. fans. Electric thermometers are placed in the bottom and top tiers of fruit packages and as soon as the fruit is entered, the doors are closed, the fan set in motion and the cooling started. By means of the electric thermometers, the temperature of the fruit is taken from the outside and as soon as sufficiently cooled for shipment (38 to 40 deg.), loading takes place. Fruit once cooled down must not be exposed to the warm air until it reaches the market and therefore a cold corridor extends from the pre-cooling rooms with an adjustable vestibule to the refrigerator car door. Through this, the trucks of cooled fruit are run directly into the cold car, thus preventing exposure, rough and unnecessary handling of packages and greatly cutting down the work and time necessary for loading.

The season of 1914 has been an active one at the Grimsby plant, although there was no peach crop to handle. Cherries, pre-cooled and shipped to Winnipeg, arrived there in splendid condition and were sold on commission at 60 cents per basket, while at the same time other sour cherries were sold in the Winnipeg markets for from 38 to 42 cents, which speaks for the superior quality of the pre-cooled fruit. The plant acted also as a cold storage and effected great savings to the growers. In one case during the raspberry season when the canning factories were unable to receive berries that had to be handled at once, as much as four and a half cars of fruit were brought to the plant, placed in a low temperature for two or three days until the factories were again in shape, thus avoiding a certain loss of over $3000.

An interesting experiment was tried in the handling of Red Astrachan apples. These apples usually go at a fairly low price but between their season and that of the Duchess, there is a scarcity of early apples. A shipper placed his apples in cold storage prior to August 15 and then marketed them as they were demanded by the trade during the latter part of the month with a gain on the transaction.

In addition to the commercial use of the plant, an experimental scientific cold storage laboratory is connected with it and its work is of great value to the grower. As an example of what it is doing, the author cites the work done with tomatoes. Tests were made on Narliana, Chalk's Jewel and Danish Export picked at three different stages of ripe-

ness and stored in eight different kinds of packages at 32, 39 and 45 deg. It was found for example that the first two kinds are of little use for cold storage and that most of the Ontario varieties of tomatoes are too likely to crack about the stem end. A small size of tomato stores better than a large one. For storage, the tomato needs to be picked when turned to a straw color; if picked riper, it will soon become soft in storage. Tomatoes wrapped separately in the 4-basket plum crate of British Columbia kept better than those stored in open baskets. Placing the tomatoes in wood-wool proved better than wrapping, while storing in a box with a sawdust filler kept the tomatoes in the best shape, especially where they were cracked. As an illustration of the value of this class of work, the writer cites the case of a grower who came to the plant and wanted to store a carload of tomatoes until Christmas time and get the special price paid for hothouse tomatoes. He was advised against it and he would have lost the entire car had he stored the varieties of tomatoes grown.

As a matter of fact, to pre-cool fruit does not necessitate an elaborate and expensive plant. Anything that lowers the temperature of the fruit previous to shipment tends to check its ripening process and postpones decay. In British Columbia experiments have been carried on by the Provincial Department of Agriculture to show the beneficial results of using the cold night air that they have in that region and also of picking raspberries in the early morning while the dew is yet present and then removing the moisture by fanning in a dehydrator before shipping. Such an appliance cost only about $25 or $50, and its success made the growers quite enthusiastic. The practice of wet picking, however, is not to be encouraged where plenty of dry weather is to be had.

In pre-cooling fruit for express shipments, extreme care must be exercised not to overdo the work. In a series of investigations on strawberries, cooling has been found beneficial when carried on on the average of about 5 deg. below the temperature of the express cars. When cooled lower than this, the berries suffer on account of the condensation of moisture on removal from the cooling chamber, with a resultant growth of mold which was as bad or worse than when shipped hot from the patch. It must also be understood clearly that pre-cooling is not a panacea and will not make overripe or injured fruit arrive in good condition. At the Grimsby cold storage plant, it is the practice to refuse to receive fruit which is not in good condition, and the loading of cars is also properly controlled. On all long distance shipments, the fruit is raised 4 in. from the refrigerator car floor on a slotted rack and loaded so as to leave continuous air spaces. In the center of the car a space of from 2 to 5 ft. is left for air circulation and the loads in either end of the car are held rigidly in place by bulkheads and proper braces, which is considered about the most effective way of preventing trouble from broken packages. (4 pp., *pdh*).

## RAILWAY CLUB OF PITTSBURGH

*Vol. 14, No. 1, November 27, 1914, Pittsburgh, Pa.*

Forged and Rolled Steel Pistons. W. W. Scott, Jr.

The paper discusses the use of forged and rolled steel pistons in modern locomotives, mainly as a means of reducing the weight of reciprocating parts and thus decreasing the dynamic disturbances at the rails.

As late as 1896, a committee of the Master Mechanics' Association, in a report on Reduction of Weight of Reciprocating Parts in Locomotives, called attention to the mutual relation between first cost and weight of reciprocating parts, with the main emphasis on the former. Now, however, with a tremendous increase in tonnage, weight of locomotives, wheel loads, etc., the question of weight has become as important as, if not more than, the first cost. The electric locomotive is now almost perfect so far as balance is concerned, as there are practically no reciprocating parts to be balanced. That is why the record of over 130 miles per hour made by an electric locomotive in 1903 has not yet been equalled by any reciprocating steam engine in either this country or abroad. The fastest time for a steam locomotive of which there is authentic evidence, made on the S. F. & W. on March 1, 1901, is 107.9 miles per hour and that for a very short run.

The speed of a steam locomotive is limited by the steam capacity of the boiler, and also by the liability of the locomotive to "jump the track" at excessive speed, for the reason that the vertical pressure on the rail due to centrifugal force of the over-balance in the driver increases as the square of the velocity regardless of what proportion of reciprocating parts weight is counter-balanced. Thus in every case there is a natural effort on the part of the wheels carrying the over-balance to rise from the rails at high speed. In addition to that, the author affirms that the over-balance in the drivers hammers the rails when the locomotive is in motion, and that rails do not crystallize but are broken by the centrifugal force of the over-balance coming at the time when the track is frozen rigid and cannot cushion the shock.

The speaker claimed for the rolled steel piston the following two advantages,—first, reducing the weight of the reciprocating parts and second, reducing the cylinder wear; in fact, he questions whether it would not be wise to rule that no locomotive (passenger at 70 miles per hour and freight at 45 miles per hour) shall show an impact on the rail due to over-balance more than 30 per cent within the static weight on the drivers. A similar rule is strictly adhered to by the Pennsylvania Lines East of Pittsburgh where no engine is allowed to show more than 30 per cent dynamic augment at above speeds. German railways allow only 15 per cent dynamic augment at high speed while the average for this country is 62½ per cent.

The author gives the Pennsylvania Railroad formula for calculating counter-balance required at the tread of a driving wheel based on the dynamic augment of 30 per cent, as well as the constants worked out by the Baldwin Locomotive Works for calculating dynamic augment for locomotives already in service. The author shows the advantage of light reciprocating parts on the axles of locomotives recently developed by the Pennsylvania Railroad and the Baldwin Locomotive Works and proceeds to the description of a new method of manufacturing pistons developed by the Carnegie Steel Company at its Homestead Car Wheel plant. The ingots are cast according to the usual open hearth furnace practice in moulds 22 in. by 22 in., about 6 to 7 ft. long. After stripping and soaking in the furnaces, they are rolled into round blooms, 15 in. in diameter and while hot, sheared into "cheeses" of the proper weight to produce the required section. The important element is the further forging and rolling work and it is very important to bear in mind that the blocks are now sheared from rolled rounds into the form of discs rather than from flat slabs into the form of squares,

as was done some time ago. This difference in procedure is the keystone of the present day success of rail steel sections and various types of wheels and is due to the fact that the outside of the ingot which according to the nature of the elements composing it, is its best part, finally becomes by this process the outside or periphery of the section while the center, naturally the weakest part, finally becomes the core and goes back into scrap.

After inspection, the discs are taken to the wheel plant. There by means of a steel dog running between two rails, the disc is transferred to a hydraulic press, the function of which is to pierce a hole considerably smaller than the rough bore desired, about half way up from the center on the axis of the disc, in order that the disc can be held between the rolls on a pin until the hydraulic pressure applied grips the piece and forging commences.

The author describes in detail the mills used and the exceptionally heavy equipment necessary to work high carbon steel into annular sections. After rolling, the piece is put through a shear which automatically trims it of the flash usually present in flat forging. In the same machine the core is punched out, thus freeing the steel of any undesirable segregation that may happen to be present after the discard from the round bloom has been made at the blooming mill shears.

An experiment was made to trace the movements of the center of the ingot during the process of manufacturing an annular section. A bar of copper 1 in. in diameter was inserted in the hole drilled through the axis of the disc while cold. The disc was then heated and worked in the usual manner. After the core had been punched out, it was split longitudinally with the copper bar. The latter was found to have varied from its original position slightly less than an inch, the maximum variation from the center line occurred about half way through the section, indicating that the steel had been thoroughly worked all the way through.

Among other things, the author takes up the question of the working of the piston against the cylinder. He states that a close investigation will show that a fair percentage of cylinders wear on the top side due in part to inferior line guides, loose crossheads and to the fact that when the locomotive is working under steam, the pressure works first under the piston rings and tends to throw the piston forward against the top of the cylinder. In order to prevent the piston from scoring the cylinder's face, the author suggests following the practice of designers of heavy stationery engines when using solid rolled steel pistons in locomotives; to cut one or more dovetail grooves in the face of the piston, insert segments of good malleable bearing metal and hammer it solidly into the dovetail grooves. This has an added advantage of forming an oil groove or pocket between the piston rings and bearing metal face. Another suggestion is two rings of bearing metal. The solid rolled steel pistons for the Pennsylvania Railroad are used with extended hollow piston rods which have the advantage of reducing the cylinder wear and simplifying lubrication.

The author states that he has made laboratory tests of a new plate ring metal which showed an "exuding" point of 1150 deg. fahr., which can be easily pinned into a dovetail groove $\frac{1}{4}$ to $\frac{3}{8}$ in. deep and which has an average scleroscopic hardness of 8.

## SOCIETY OF MECHANICAL ENGINEERS, TOKYO, JAPAN

*Journal, vol. 17, Tokyo,*

*No. 34, September 1914*



*No. 35, October 1914*



### The Distribution of Stress in a Tension Strap Having a Circular Hole Filled with a Plug, K. Suehiro.

The paper is an extension of a previous paper entitled The Distribution of Stress in Plates having Discontinuities and Some Problems Connected with it. (Published in *Engineer* in 1911).

In the present paper, the author treats mathematically the case of plane stress where the plate is not only strained in its plane but also in the direction of the normal to the plane. It is assumed that a rectangular thin elastic plate is pierced with a circular hole in its center and filled with the plug and that it is then subjected to edge traction in its plane, normal to the sides, the breadth of the plate being supposed to be sufficiently large as compared with the size of the hole so that the displacement of a distant point is not influenced by the presence of the hole. It is next assumed that the plug is of the same material as the plate and just fills the hole without exerting any initial stress on the plate. The author treats the problem by a strictly mathematical method and comes to the conclusion that an engineering structure can be partially relieved from stress concentration due to the presence of the hole by filling the hole with the plug (11 pp., 3 figs).

### Theory of Elasticity of Rods Whose Center Line is a Space Curve, T. Matsumura.

The paper develops a general theory of elasticity of rods whose central line is inside curve, this theory being then applied to the problem of spiral springs.

In the course of his investigation the author develops the main questions governing the deformations of such rods and shows how they can be applied to the determination of the deformation of cylindrical spiral springs: first, when a spring is held at one end and subjected to tension by an axial load applied at the other end and second, when the cylindrical spring used in a shaft governor, revolves around the shaft in the plane perpendicular to it. In each case when the angular velocity is high, the elongation is considerably affected by the centrifugal force of the spring itself.

### Transversal Strength of Wire Guns, M. Okôchi.

The article discusses the question of transversal strength of wire guns, a problem which has hitherto been treated

with respect to one particular type and which the author attempts to treat in a more general manner. He establishes the fundamental equation for the distribution of stress in a thick, walled hollow cylinder of which the surfaces are exposed to certain external and internal radial pressures, assuming that the distribution of temperature inside the walls of the ordnance piece (although there are no precise data to support such an assumption) occurs in accordance with the Fourier theory of the conductivity in homogeneous materials and that because of the shortness of duration of the external pressure, it is stationary. He passes then to the consideration of an equation for distribution of stresses in a supposititious wire gun having no solid core and made exclusively of thin wire, and from this, to the consideration of a wire gun with an inside core for which he derives an eqnation showing the distribution of stress in three directions, both in the core and in the wire elements and also gives expressions for the total stresses in the wire gun at the instant of discharge. Among other things, he shows by his formula for the stress in the wire both in the stationary state and at the instant of discharge, that different states of stress can be obtained with the winding tension maintained constant and derives an expression for the winding tension giving equal tangential tensions.

He proceeds then to the consideration of the strength of large caliber wire guns of complicated structure and fully establishes the mathematical equations for stresses in such cases. Further, in order to facilitate the calculation of the strength of wire guns by his formula, the author gives a table showing the values of the co-efficients used therein. The matter is handled in a strictly mathematical manner and therefore is not suitable for abstracting.

## WESTERN SOCIETY OF ENGINEERS

*Journal, vol. 19, no. 10, December 1914, Chicago.*



### Coon Rapids Low Head Hydro-Electric Development on the Mississippi River near Minneapolis, J. W. Link.

Description of the low head hydraulic development with a total fall of about 165 ft. or an average fall per mile of 2.75 ft.

One of the most interesting features of this construction is the way the foundation is set up. Owing to the wide variety of ground encountered, a hollow structure is carried on piles so as to insure against unequal settling as much as possible. The possibility of a blowout against the structure was provided for by enclosing the whole area of the dam and powerhouse with steel sheet piling, driven to such a depth as to penetrate well into what was assumed to be impervious material, that is, impervious under the pressures which are present in this particular case. A working load of only 10 tons per pile was allowed under all of the structures except the powerhouse, such a load limit being used in order to have a closer spacing of the piles and thus insure a more uniform distribution of the loads. In driving the piles careful watch was kept of the penetration and the bearing value of the pile was figured by the Engineering News formula. At the south end of the spillway where compact clay rises to the bed of the stream, it was found impossible to drive either sheet steel piling or round piles and instead of that, concrete walls were substituted, the concrete being placed in the trenches without forms. A method of carrying on the excavation was used which involved driving the pile after the excavation was completed. This resulted in the heaving of the bottom and the distorting of the braces but the work was carried through to a successful finish by tying the bracing down to the heads of the piles already driven. This did not entirely stop the distortion and buckling of the bracing but prevented it from collapsing. Provision was made in the foundation for taking up the horizontal forces so as to prevent movement of the structure down stream. This was done partly by driving inclined piles and also by carrying out buttresses down stream between the draft tubes, each buttress resting on a cluster of 32 piles driven to refusal.

The Tainter gates used in the plant have no cross bracing. They are built up of I beams which span the opening and are attached to plate girders at the end. From the girders, struts extend to the pins which support the gates and upon which they hinge. Between the beams and the struts gusset plates are inserted instead of the usual cross bracing, the cover plates being riveted to the flanges of the I beams. Gates formed in this way will require somewhat more metal and will possibly cost slightly more than the others, but have the advantage of being less liable to damage in case they are overtopped by flood. They are made watertight on the bottoms and ends by the use of rubber belting. The hoists for these gates consist of two stands with chain drums driven by a worm gear, the worms in their turn being driven by a line shaft in one piece. The hoists are arranged for hand or electric motor operation, the latter being provided only for emergency cases where it is desired to open the gates quickly; so far, no motor has been installed.

The expected annual output from the plant as it stands (5 units) is 52,000,000 kw-hr. and 64,000,000 kw-hr. from the complete installation of 7 units. The generating units are of the vertical type consisting of Allis-Chalmers single-runner Francis turbines direct connected to General Electric alternators and fitted with roller thrust bearings and oil pressure governors. The turbine runners having a mean diameter of 8 ft. 6½ in. and a diameter over the discharge ring of 12 ft. 8 in., are set in concrete scroll cases with cast iron pit rings. The wheel gates, which control openings 54 in. high by 13 in. wide, are of the swivel type with exterior operating ring and links.

The rotating element of the machine is carried by a roller thrust bearing which rests on the upper spider of the generator, and the length of the shaft from the center of the runner to the top of the roller bearing is 21 ft. 6 in. A water lubricated lignumvitae guide bearing is carried by the upper cover plate of the turbine and an oil-lubricated guide bearing is carried by the upper spider of the generator just below the roller thrust bearing. The shaft has a flanged coupling 3 ft. 7 in. above the lower guide bearing. The lubrication of the roller bearing and the upper guide bearing is secured by a unit oiling system. The oil filter, storage tank, and circulating pump are located in the wheel pit. The motor-driven rotary circulating pump is mounted on the oil tank and forces the oil up to the bearings, the return of the oil to the filter being by gravity (37 pp., 25 figs. *d*).

## MEETINGS

### LOS ANGELES, JANUARY 15

A very successful meeting of the Los Angeles Section was held on January 15. Prof. Walter H. Adams read a paper on the "Diesel Engine and its Application to Southern California. The paper was of particular interest in view of the extensive oil development in Southern California, and it was discussed by Messrs. Clark, Clapp, Harris, Finkle, Gerhardt and Weeks.

### MINNESOTA, JANUARY 28

On January 28, the Minnesota Section held a joint meeting with the Western Association of Electrical Inspectors which was holding its annual convention in Minneapolis. At this meeting, Charles L. Pillsbury, past vice-chairman of the Minnesota Section, gave an address on the Principles Entering into Valuation of Public Utilities and Rate Making. Mr. Pillsbury gave a very strong address and treated especially some of the fundamental principles involved in rate making and valuations of public utilities, citing from a large number of supreme court decisions as his authorities.

### NEW YORK, FEBRUARY 9

At the monthly meeting of the Society in New York, held on February 9, an address was delivered by Edwin J. Prindle, of New York, a patent expert, on A Proposed System of Classifying and Digesting the Records of the Society to Render Immediately Available all Information on Each Branch of Every Subject. Mr. Prindle proposed an ambitious plan of indexing technical literature with special reference to not only properly classifying all the valuable information contained in the records of the Society, but also so digesting all papers and articles in the records that each phase of every subject treated shall be referred to.

This will, he thinks, obviate the necessity of patiently going through every paper page by page to ascertain whether the information desired is available. The plan is based on the experience of the United States Patent Office in classifying inventions in general and mechanical inventions in particular. Mr. Prindle explained the system of digesting law books in considerable detail, and pointed out the features so thoroughly tried there, which are applicable in a corresponding system for the Society's records. He showed illustrations of the record cards that would be used in the system proposed and indicated the various forms that the indexing would take for classifying different subjects.

The proposed plan was extensively discussed. In general, it met with favor, except that the majority of the discussors expressed regret that it should be limited to the works of the Society alone, whereas the plan could be made so much more useful by extending it to cover the transactions of the other great engineering and technical societies. The difficulties of a work of this magnitude were then pointed out, and much general discussion followed, notable among which was the suggestion in a written discussion from Henry Hess that the matter be laid before the Engineering Foundation, recently established in New York for promoting research work.

### MILWAUKEE, FEBRUARY 10

At a meeting of the Milwaukee Section on February 10, L. G. Warren, resident Engineer, gave a lecture on the new Linwood Avenue Intake tunnel.

The paper describes the construction work done on the tunnel and shaft. The contract was executed by Joseph Hanreddy & Company of Chicago, Illinois.

The compressor plant was operated by motors from current taken from the local electric company. It consisted of a 2 stage Ingersoll Imperial type No. 10 compressor, capable of delivering 1,000 cu.ft. of air per minute and two single Ingersoll Imperial type compressors capable of delivering 700 cu.ft. of air per minute. The first compressor was used to furnish air to the drills and pumps in the tunnel and the second for furnishing air to the tunnel when it was under air pressure and also for furnishing air to the pumps in emergencies.

The method of excavation is described in considerable detail. The material encountered consisted chiefly of red clay, hard pan and brown shale, the latter requiring blasting for removal. In the completed shaft, the hoist form was made of 12 x 12 timbers. It is divided into two compartments each provided with guides for one cage. Two cages operated on a breast cable by means of an electric hoist, were in constant operation. These cages then conveyed both the in-going and out-going mules and also the laborers. A set of air locks were installed at station 0 plus 75. It consisted of one material lock and one man lock. The material lock is composed of $\frac{3}{8}$ in. boiler steel, being 7 ft. in diameter and 20 ft. long. The man lock is composed of $\frac{3}{8}$ in. boiler steel, being $3\frac{1}{2}$ ft. in diameter and 12 ft. long. It has been necessary to use these locks for one emergency, which will be described later.

All of the concrete was mixed in a one-yard Smith Mixer situated on the surface. From the mixer, the concrete is dumped into the tunnel cars and then by the cage into the tunnel where it is hauled by mules into the forms. The forms are composed of steel plates and angles with the side walls and arch forms separate. Each of these forms rests on wheels which are supported on movable rails, so that the forms can be advanced by means of the hoisting engine on the side wall form. The side walls and the arch are placed by separate operations, the side walls being placed in advance of the arch. About 100 feet of the invert has been placed adjacent to the shore shaft, leaving the remainder to be placed after the completion of the arch and side walls. The reinforcing rods in the side walls are driven 18 in. into the shale bottom, so that they may be removed by excavating beneath the side walls, and a bond secured with the reinforcing rods in the invert when the invert is placed.

The paper describes in detail the water inflow system used as well as the method of ventilation. The latter was effected by a 6 in. fan, rated at 3675 cu.ft. per minute.

For warning measures, two miners' safety lamps are constantly maintained in the heading, one suspended on the timber above the platform for the forms for concreting the side walls and one suspended on the roof timber about 8 ft. back of the face of the heading. The City's inspectors, and the contractor's men have been instructed in the use of these lamps for the detection of methane.

BUFFALO, FEBRUARY 11

At a meeting of the Engineering Society of Buffalo on February 11, C. H. Bierbaum delivered an address on Bearings and Their Lubrication. Mr. Bierbaum has been making a special study of this question for the past seventeen years and gave a very interesting lecture which was fully illustrated by drawings on the blackboard. He explained the fundamental principles connected with the design of bearings and arrangements which should be made for their proper lubrication. His address was interspersed with accounts of actual tests which have been made and troubles which have been remedied from actual practice. In addition, he explained the various formulae, etc., which have been developed in connection with this work and the concensus of opinion from the members after the lecture was, that he had presented one of the most interesting addresses so far given and one which was of great practical value to the 120 members present.

ATLANTA, FEBRUARY 12

A meeting of the Atlanta Branch of the Society was held on February 12. The meeting took the form of a luncheon at which a general discussion took place relative to the welfare of our local branch and prospects for the future. It was decided to hold these luncheons once a month in order for the local members to keep in closer touch with each other and to advance the general interests of the branch.

BOSTON, FEBRUARY 15

The Sixth Annual Joint Engineers' dinner was held on February 15 and was the first public function to be held in the new Boston City Club Building. Among the speakers were the following: His Excellency Governor David I. Walsh, Dr. Allan McLaughlin, Mr. Charles H. Eglee, Captain Robert W. Bartlett, the Presidents of the Local Engineering Schools and the Presidents of the Engineering Societies. There were about 250 in attendance.

## NECROLOGY

JOHN HENRY CLARK

John Henry Clark was born in Cornwall, England, on April 7. 1859. As a young man, he served an apprenticeship as a machinist in the shops of Cooke, Rymes and Company at Charlestown, Mass., and also with the Whittier Machine Company in Boston, Mass., and afterwards became superintendent of the works of the latter company. He was also associated with Hon. Oliver Ames, formerly governor of Massachusetts, who was interested at that time in the development of an oil engine.

In 1890, Mr. Clark took a position with the Thomson-Houston Motor Company which was one of the companies affiliated with the Thomson-Houston Electric Company for the purpose of exploiting the electric elevator business. This company afterwards became merged in the General Electric Company which was organized in 1892. When its power and mining department was formed, Mr. Clark was connected with it and continued in that department until his death. He was transferred from Boston to Schenectady in 1895.

Mr. Clark was a member of the Boston Engineers' Club and the Engineers' Club of New York. He died at Schenectady, January 3, 1915.

CHARLES WARD

Charles Ward was born in Leamington, England on March 5, 1841 and came to America in 1871. He had been trained as a gas engineer in England and almost his first work in America was in Charleston, West Virginia where he installed the first gas works. He later became superintendent and general manager of the company.

Mr. Ward came into prominence before the engineers of the country when the late Admiral Melville invited the makers of water tube boilers to compete for supplying the boilers of the coast defense vessel Monterey. Mr. Ward's boiler was tested in 1890 and proved so noteworthy for the length of the test under severe conditions and attained such excellent efficiency that four boilers of this type were installed on the Monterey. Mr. Ward thus has the credit of the first installation of water tube boilers on a large war vessel.

Even before this, smaller water tube boilers of a different design manufactured by Mr. Ward had been used in steam launches of the United States Navy and they have given such satisfaction that the Navy Department has continued their purchase and use to the present time.

Mr. Ward was also a pioneer in the use of screw propellers on western river steamboats in the effort to reduce waste and increase efficiency as compared with the time honored stern wheel boats, which are almost exclusively in use. Some years ago, he carried out a repetition of the famous test in England during the first half of the last century of a tug of war between a screw propelled boat and a stern wheel boat of the same power. In the later case as in the earlier one, the screw propeller showed the better results.

Mr. Ward died in Charleston, West Virginia, on January 17, 1915.

HENRY SELBY HAYWARD

Henry Selby Hayward was born at Brooklyn, Long Island, September 19, 1845. His parents moved to Elizabeth, N. J., in 1852; was educated at Rev. David H. Pierson's School in Elizabeth; entered the Novelty Iron Works at the foot of Twelfth Street, New York, in 1862, and there served a four years' apprenticeship in marine construction work and engineering.

In July 1866, he entered the service of the Pacific Mail Steamship Company and made a voyage on the steamship "Montana" through the Straits of Magellan to San Francisco. He was sent back to New York via the Isthmus of Panama and returned in July 1867, on the steamship "Great Republic," to San Francisco, via Straits of Magellan, as assistant engineer. The "Great Republic" sailed from San Francisco for Japan in September 1867, the first regular steamer on the Japan and China route of the Pacific Mail service. After several voyages between San Francisco and Hong Kong, he was detailed to service on branch lines and spent about four years' service on the steamers "Hermann," "New York," "Costa Rica" and "Arizona," plying between ports in Japan, China and Siberian coast. During that period he filled positions as second and first assistant and acting chief engineer on the different steamers.

Mr. Hayward returned home November 1872 on three months' leave after six years of continuous service, but while home he decided to resign, and entered the service of the Pennsylvania Railroad Company April 1, 1873, as machinist

in the Altoona shops. He was subsequently detailed to duty in draughting room, and in 1874 was detailed for special duty on the United Railroad of New Jersey Division, with title as assistant road foreman of engines. He was appointed assistant superintendent of motive power, United Railroad of New Jersey Division, April 1, 1875, to which the marine department was subsequently added in 1881.

On October 1, 1882, he was appointed superintendent of motive power of the United Railroad of New Jersey Division, and was also made superintendent of motive power of the West Jersey Railroad in 1883, and the Camden & Atlantic Railroad, including the ferries and floating equipment on the Delaware River, in 1884. He had supervision of the motive power and marine equipment of the New York, Philadelphia & Norfolk Railroad from January 1, 1890, until his death.

During the 80's he took out several patents, one being for an interior check valve on locomotive boilers, another for a car journal box, and still another was a cut off valve for beam engines. This cut off valve was practically adopted by all the ferries in New York Harbor.

He had been a member of the American Society of Mechanical Engineers since March 1, 1882, and of the Society of Naval Architects and Marine Engineers since May 1893. He was also a member of the Engineers' Club of New York, the Engineers' Club of Philadelphia, and the New York Railroad Club.

## PERSONAL NOTES

James F. Monaghan, until recently associated with the Waltham Bleachery & Dye Works, Waltham, Mass., has opened an office in Boston, as an engineer and specialist in the engineering of processes and equipment relative to the bleaching, dyeing and finishing of cotton and linen piece goods.

James A. Gish, Jr., has become affiliated with the Nebraska Portland Cement Company, Superior, Neb., in the capacity of plant manager.

Alfred C. Nelson announces that he has opened offices in the Rockefeller Building, Cleveland, O., as consulting and contracting engineer.

William H. Smead has closed his office in the Citizens Building, Cleveland, O., and has taken charge of all mechanical work for the welfare department of the City of Cleveland, including designing new power house plant and heating plant at the new City Hospital, and mechanical improvements at the Cooley Farms.

Egbert Moxham, until recently associated with the E. I. du Pont de Nemours Powder Company, Wilmington, Del., as assistant manager of the development department, has accepted the position of general manager of the Aetna Explosives Company, New York.

George F. Murphy is now associated with the Heine Safety Boiler Company and will have charge of their sales offices at Pittsburgh, Pa. He was until recently sales representative in charge of the eastern branch office of Busch-Sulzer Bros.-Diesel Engine Company of St. Louis, Mo., with headquarters in New York.

The following members of this Society have been elected to offices in the Engineers' Club of Philadelphia: J. W. Ledoux, President; D. Robert Yarnall, Vice-President; L. H. Kenney, Secretary; J. E. Gibson, Director.

## STUDENT BRANCHES

### ARMOUR INSTITUTE OF TECHNOLOGY

The fourth regular meeting of the Armour Institute of Technology Student Branch was held on the evening of February 4. F. L. Faulkner '15 presented a paper on the Adaptability of the 8 Cylinder V-Type Motor to the Automobile. Slides were used to show the different types. A general discussion followed the paper.

### BROOKLYN POLYTECHNIC INSTITUTE

The first meeting of the Brooklyn Polytechnic Student Branch was held last October. At this meeting, Theodore B. Merkt gave a very interesting lecture on Sun Power Plants.

Another meeting of the Branch was held on November 7. J. A. Kinkead of the Parkesburg Iron Company gave a very interesting lecture on Charcoal-Iron Boiler Tubes and George Wieber talked on Diesel Engines—Their Application to Marine Work.

At the meeting on January 9, Arthur V. Farr of the S. K. F. Ball Bearing Company gave a talk on Present Day Applications of Ball Bearings.

The fifth meeting of the Polytechnic Student Branch was held on February 6. The meeting was unique in the fact that for the first time student papers composed the evening program. Three papers were presented: Ice Making by Samuel P. Blakeman; Friction Losses in Universal Joints by Murray Harris; and Present Day Locomotive Practice by Merritt Van Valkenburgh.

### CASE SCHOOL OF APPLIED SCIENCE

On February 11, at a meeting of the Case School of Applied Science Student Branch, Russel C. Manning '15 gave a paper on Electrification of Steel Mills. He discussed reasons for installing the electric drive in rolling mills as against the steam drive as used formerly. It showed that though the first cost was greater, the economy of operation of large producer gas engines direct connected to the alternating current generators offset this increased first cost to such a degree that they were coming more and more into use. The method of operation of the mills when driven electrically was discussed and the fact was brought out that even in the case of reversing mills, motors were proving more effective; a few power and cost figures were given to show this. The paper was discussed by A. P. Armington, L. K. Baker and L. W. Hodons.

### COLORADO AGRICULTURAL COLLEGE

A meeting of the Colorado Agricultural College Student Branch was held on January 18. Mr. Searles gave an interesting review of the article Steam Locomotives of To-Day from The Journal of January, 1915.

Professor Crain then gave a short talk on the Locomotive Testing Plant at Purdue.

### COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch on January 8, Prof. Sidney A. Reeve, formerly of Worcester Polytechnic Institute gave a lecture on Heat and Work. Professor Reeve by clever and interesting analogies gave a very clear conception of heat and entropy. He compared our oceans of water to the oceans of temperature surrounding us toward which all temperatures fall. Further comparisons with the mechanics of motion, movement of celestial bodies, molecular motion and vibration proved interesting and extended the vision on the subject.

### CORNELL UNIVERSITY

The Cornell University Student Branch held a meeting on January 22, at which Elmer A. Sperry, President of Sperry Gyroscope Company, Brooklyn, N. Y., gave a lecture illustrated with lantern slides and experimental demonstrations on the theory of the gyroscope, its present applica-

tions and the widening field for its use. In naval use, it proves its worth as a compass, as a stabilizer for the ship itself or for telescopes, horizon finders or the like, for recorders of pitch, roll and angle of yaw. It has similar uses on aerial craft.

### KANSAS UNIVERSITY

On January 21, at a regular weekly meeting of the Kansas University Student Branch, O. H. Ruth gave a report of his visit of last November to the plant of the Western Electric Company at Hawthorne, Ill. His talk was general and by means of a chart he showed the layout of the entire factory and the arrangement of the buildings and pointed out the advantages of such an arrangement. Some stress was laid upon the shipping facilities and the ware-housing methods of the company. He spoke also of the advantages offered by the company to its employees in the way of protection of health, physical exercise, social amusement, etc. Quite a lengthy discussion followed among the members of the Senior Class who visited the plant on their fall inspection trip.

Dale S. Mills reported on the Industrial Engineering magazine. He chose for his subject the refrigerating plant of the Sargeant Wharf Station of the Quincy Market Cold Storage and Ware-house at Boston, Mass. Most of his discussion was on the new 1000 ton compressor used at this plant, which is the largest compressor ever built, and spoke somewhat in detail of the construction of the parts for this massive machine.

At a meeting held on January 28, at the home of Dean P. F. Walker, Prof. C. C. Young of the water analysis department of the University of Kansas gave a lecture explaining the causes and effects of bad water used for feed water in boiler plants. He also showed how boiler scaling could be prevented by different means of water softening and cited instances where such prevention has been successful, and pointed out the fact that any boiler plant can save money by installing a water purification plant instead of using the old means of removing scale with tools for that purpose, except in a few very rare cases where soft water is available. Not only does the installation of such a plant save on labor, but very materially saves on the life of the boiler. A good discussion followed by Dean P. F. Walker and Prof. A. H. Sluss, Superintendent of the power plant at the University of Kansas.

### LEHIGH UNIVERSITY

At a meeting of the Lehigh University Student Branch on December 10, W. F. Roberts, superintendent of the Lehigh Plant of the Bethlehem Steel Company gave a paper on Ordnance.

W. J. Bailey, special student at the University read a paper on Naval Architecture.

### MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The Mechanical Engineering Society held its first meeting since the mid-year vacation on February 17. This was the first lecture meeting for some time, the most of the activities of the Society this year having been confined to trips to various large factories.

Harry Gay of the Stone and Webster Engineering Corporation gave a most interesting talk on The Equipment of the new Technology. Mr. Gay confined himself more to the administration connected with the equipping the new buildings than to the pieces of apparatus and the like which are being installed. His talk showed very well the vast amount of work which must be done to avoid errors in the final product when so much is at stake. His remarks also showed very well the nature of the work in an up-to-date drafting office.

### OHIO STATE UNIVERSITY

At a meeting of the Ohio State University on January 14, W. A. Converse chemical director of the Dearborn Chemical Company of Chicago addressed the members of the branch on Treatment of Boiler Feed Waters. As the engineer is usually more or less familiar with the scale forming action of water, Mr. Converse limited his talk to the corrosive action alone, which until quite recently had received little attention. He stated that waters containing no scale forming substance were not necessarily harmless, but might be highly corrosive. He cited a case where the analysis indicated the water to be very satisfactory but that it corroded or dissolved the pipe lines through which it passed so badly that it was necessary to replace them once every six months.

The speaker discussed briefly the physical and chemical properties of water and traced its passage from the vaporous condition in the clouds through the atmosphere, the surface of the earth and the lower strata of materials, and told just what substances were absorbed, and also discussed several typical analyses of boiler feed waters and indicated how the engineer is likely to be deceived.

The causes of pitting and some of the modern theories of electrolytic action were spoken of, and lantern slides illustrating experiments which tended to prove these theories were presented.

### PENNSYLVANIA STATE COLLEGE

At a meeting of the Pennsylvania State College Student Branch on January 18, the following officers were elected: W. D. Garman, president, V. D. Longo, vice-president and J. L. Sprenkle, secretary.

### STEVENS INSTITUTE OF TECHNOLOGY

On Wednesday, January 16, a party of eighteen students under the guidance of the Stevens Engineering Society visited the Otis Elevator Company's plant at Yonkers to inspect the various departments. The society was very fortunate in obtaining the privilege of visiting this plant through the kindness of the Vice-President of the company for according to rule, inspection of the plant is forbidden.

On February 10, the society conducted an inspection trip, to the National Biscuit Company's plant.

### SYRACUSE UNIVERSITY

The first important meeting of the new semester of the University of Syracuse Student Branch was held on February 9. Plans were made for conducting a series of "Personal Efficiency" lectures to be under the direction of W. C. Dexter, chairman of the branch and which are to be given at each of the bi-weekly meetings. In addition to this, they have prepared a short series of lectures on the Working of the New Workmen's Compensation Law in New York State, on the History of the Electrical Industry in this Country and on Banking.

The Student Branch voted at that meeting to challenge the Senior Electrical Engineers to a debate in the near future. Two questions will be submitted to them for their choice: Should Military Training be Compulsory in the Colleges of this country and Should Arbitration in Labor Troubles be Compulsory?

On February 12, an illustrated lecture on Submarines was delivered to the entire student body of the Engineering Department by G. E. Furbush, Secretary of the Student Branch. The history of submarine boats was traced from the crude efforts of Symons in 1747 up and through the present time. Much detailed information regarding modern practices in this country and abroad was presented. It is hoped that it may be possible to use a more complete abstract of this paper in an early issue of The Journal.

### THROOP COLLEGE OF TECHNOLOGY

At the regular meeting of the Throop College of Technology Student Branch on January 28, Paul Weeks, representative of the Baldwin Locomotive Works and a member of the Society, gave a very interesting talk on some of his experiences as an engineer. He pointed out some of the difficulties which he met with and showed how he overcame them.

### UNIVERSITY OF COLORADO

In the January issue of The Journal a brief account was given of a meeting of the Student Branch at the University

of Colorado, Boulder, at which a lecture was given by Charles M. Hampson of Denver. The lecturer discussed the square deal in engineering and the ethics involved in the work of the mechanical engineer, and it is believed that the following extracts from the lecture will be of general interest to members of other sections.

Mr. Hampson said that while the engineer of the past had to know his machine shop and foundry practice, his drawing board and steam plant, to-day he must also understand ions and ohms, amperes and resistances and must be a fair all 'round civil engineer as well. The chances are that the men who are backing an undertaking do not know the first principles of engineering and the mechanical engineer is naturally the custodian of their money and is largely responsible for the success or failure of the undertaking. It is to his advantage to have a reasonable, practical working knowledge of the essential details of engineering in its various departments.

The speaker quoted statistics with regard to salaries of engineering graduates which indicate that the average mechanical engineer receives sufficient compensation so that he can well afford to give of his best.

Speaking of the square deal, he said: Square, according to Webster, means "forming a right angle, true, upright, honest, just." Deal means a bargain or understanding. Could we have a better watch word? A right bargain. Remember this: A square deal means a true understanding.

There are no mistakes in the engineering profession; it is the only profession that does not recognize the word. A trained engineer has no excuse for a misconception. Engineering is an exact science so far as it goes. The engineer should not attempt to go further than his knowledge. When in doubt he should stop.

We all know when we are in the right and when we are not right. We all know good work, square work, and we must insist upon that sort of work or none.

In tearing down an old house in Milwaukee some years ago surprise was expressed by the workmen at the standard size of the timbers. The 4 × 4s were actually 4 in. by 4 in. and the 2 × 6s really were 2 in. by 6 in. How many houses built in these later years can show such measurements of dimension stuff?

If it were now desired to use timber in construction work that was full dimension it would be necessary to place the order with the mills well in advance and pay an additional price of at least two dollars per thousand over the regular price. Think of it; you specify a certain sized piece of timber and are then compelled to use a piece from 10 to 20 per cent smaller. How about the factor of safety? The only way to get a square deal is to specify absolute sizes and make allowance in the cost sheet.

During the past fifteen years it has been my duty to handle a great many yards of concrete work, in engine foundations, power plant walls and other work in connection with engineering projects. In almost every contract the greatest watchfulness has been necessary to insure the honest reinforcement of the structure. For some inexplicable reason the average concrete worker seems to consider the reinforcement used a sort of joke. I have seen men attempt to utilize three strands of barbed wire for a ¾ in. twisted bar. In many cases where 1 in. square bars have been distinctly specified an attempt has been made to substitute round bars with only three quarters the area. Many cases of failure in dams and retaining walls have been traced to such insufficient reinforcement.

My attention has been called by Professor Lawrence to the following ethical questions concerning the work of the engineer which I consider of the greatest importance.

Has a mechanical engineer a right to buy, invest in or sell stock in any company or corporation which may be directly or indirectly affected by his position, knowledge or influence?

Has a mechanical engineer a right to accept a commission either directly or indirectly on any material, equipment, machinery or supplies in use by the company he represents which could possibly affect his judgment?

Has a mechanical engineer any right to give out information regarding the plant to which he is giving his services to personal friends which might possibly act to the detriment, ultimately, of the concern that is employing him?

If we consider these questions at all seriously we must admit that we are confronted with a question of morals rather than ethics. The question then becomes: "Do you propose to use all your knowledge in the building up of the business that you are paid to exploit or will you use your profession to advance your own personal and private interests?"

A square deal in engineering means to me, first, a square deal to the person or company acting in the capacity of employer. In order to give this square deal, in the judgment of many of the leading engineers of the country, it is very much better that the graduating engineer should have no personal interest of any description whatever in the stock of the company or the earnings of the individual employing him. Personally I have, at times, purchased or otherwise acquired stock in companies employing me, but, in every case, I have found that it was a mistake on my part to become so interested. Self-interest is one of the most important factors to deal with and an engineer must be able to act absolutely without prejudice in order to render the best services possible in return for the compensation that he receives.

Now about giving out information concerning your work to outsiders. Here is a question that requires very careful discrimination. A man has a perfect right to feel proud of his work. Who of us do not? We are naturally anxious that our light should not be hid under a bushel; that our friends should know and appreciate what fine work we are doing, but even here let us bear in mind that our first duty is to the man that writes out the pay checks. It is so easy sometimes to start a conflagration and so terribly hard to put it out. Use most careful discrimination and if there is any doubt in your mind as to the propriety of mentioning business matters take my advice and—don't.

"Above all to thine own self be true; it must follow as the night the day thou canst not then be false to any man."

### UNIVERSITY OF ILLINOIS

At a recent meeting of the University of Illinois Student Branch the following officers were elected for the next semester: R. C. Maley, president; L. Eslick, vice-president; E. B. Stout, secretary and D. E. Miller, treasurer.

This branch has just completed a very successful semester's work. Six meetings were held in which lectures and discussions of the following nature were given: Short Cuts in Computation, by Professor Goodenough; The Quarry St. Station of the Edison Commonwealth Company, Chicago, Ill., by E. C. Pierce; The Balancing of High Speed Engines by E. S. MacPherson; Coal Hauling Machinery, by L. Eslick and Saw Mill Machinery, by O. C. Hutchinson.

The big event of the semester was the "Open House" given by the society on the evening of October 23. The object of it was to bring the under-classmen of the University into closer touch with the engineering side of college life. All the laboratories, including the machine, forge and wood shops were thrown open to inspection while the different branches of mechanical engineering were being explained, demonstrated and illustrated by slides in the various departments. Souvenirs consisting of "I" buttons turned out by the wood shop, paper weights by the forge department and M. E. watch fobs of an artistic pattern molded in the foundry were presented to the visitors. In the steam laboratory each visitor was given a chance to make himself a set of indicator cards from the various steam and gas engines while the latter were running under full load. In one corner of the big steam laboratory was a complete power plant in operation which furnished power for the

Seroco ventilating fan, and the dynamo which generated current for the large "A. S. M. E." automatic flashing sign. An ice machine in operation was demonstrated in another part of the laboratory and apparatus of various kinds were operated and explained to the visitors. There were 2000 people present.

### UNIVERSITY OF KENTUCKY

At the December meeting of the University of Kentucky Student Branch, Prof. E. F. Farquhar spoke of the advantages of the engineer who has an extensive vocabulary at his disposal over the engineer with a limited vocabulary. He spoke in general of English being a prerequisite to the engineer.

At a meeting on January 14, Minott Brooke spoke at length of extravagances of the young engineer and introduced several methods of economy among resident engineers.

### UNIVERSITY OF MAINE

At a meeting of the University of Maine Student Branch on January 22, Mr. Keppel Hall who is installing the Taylor system of Scientific Management at the Eastern Manufacturing Company's plant at Brewer, Maine, gave a talk on Scientific Management. The four main divisions that he emphasized were as follows: A close analysis of the work; close analysis of the workmen; putting the right man on the right job; making the management realize that the installation of Scientific Management was not for the sole purpose of profits for them.

### UNIVERSITY OF MICHIGAN

At a meeting of the University of Michigan Student Branch on February 11, Wallace W. Tuttle was elected as chairman and M. S. Manwaring as secretary and treasurer of the Branch.

Prof. H. C. Anderson gave a general talk in which he mentioned several of the important branches of engineering a graduate mechanical engineer might possibly get into and some pertinent facts in connection with each of them and some good advice to the members.

### UNIVERSITY OF MINNESOTA

The regular February meeting of the Minnesota Student Branch was held on February 11. Professor Shipley spoke on scientific shop management. He discussed the old military, the new Taylor and other systems now in use in various manufacturing establishments such as the Brown and Sharpe, the Tabor, and the Ford plants. He also took up in detail the various methods of compensating workmen.

### UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch on January 28, the following officers were elected for the second semester: L. L. Leach, chairman; Troy Russell, secretary and treasurer; P. R. A. Nolting, corresponding secretary. A governing committee consisting of Prof. H. Wade Hibbard, honorary chairman, Prof. G. D. Newton, Stanley Goodman and J. C. Squires was appointed.

A special business meeting was held on February 5. At this meeting the terms of membership which were offered by the St. Louis Engineers' Club were accepted. The Club offers to members of student societies the privilege of Junior Membership at one-half the usual rates for initiation fee and annual dues. In addition to create interest among the student members, free associate membership carrying with it remission of initiation fee and dues for one year is offered to the student who shall present the best paper before the technical society of which he is a member.

The Engineers' Club in order to coöperate further with the student members and extend its field of usefulness offers to suggest speakers who would be willing to address student societies, to print in its May or June bulletin the names of members of student societies who desire to secure summer employment and to print in its Year Book a list of student societies and their officers. Further, the Club offers to participate annually in one joint meeting arranged by a student society or a group of coöperating societies, to grant to the student members the facilities of its Library in exchange for a similar privilege to its own members in available university libraries, and to make an appropriation from time to time to assist a student in the making of an original research provided the recipient of such financial aid shall have the endorsement of the faculty of the institution with which he is connected and the approval of the Executive Committee of the Club. In such cases, the Club reserves the right to exclusive publication of the results of the investigation in its own Journal of Proceedings. The Club agrees to invite whenever possible, the members of the student societies to go with them on various excursions which it may have.

The resignation of the present corresponding secretary, P. R. A. Nolting was accepted. J. O. Royse has been elected in his place.

### UNIVERSITY OF NEBRASKA

On January 12, at a meeting of the University of Nebraska Student Branch, L. F. Shedd of Chicago gave a very interesting lecture on the birth and progress of the Safety First and Prevent Injury Movements. He told how the railroad employees were taught the principles of the movement, and used stereoptican slides and motion pictures to show many of the careless practices of the employee and trespasser and their correction. Statistics were given to bring out the effects upon loss of life and limb that the movements are having.

At a meeting of the Branch on February 2, Dr. J. Stanley Welch, a graduate of the University of Nebraska and one of the greater medical and surgical authorities in the central west, gave a very interesting and practical lecture on First Aid to the Injured. He brought out very clearly those things which are of prime importance and the order in which assistance should be rendered to obtain the best results. Following the lecture, he gave a demonstration upon one of the students of the first aid methods of treatment of the most common injuries. The demonstration included the removal of a foreign substance from the eye and its treatment until a doctor could be obtained; bandaging and putting splints on a fracture; stopping excess loss of blood; treatment of a wound; artificial respiration; how to make and sterilize a bandage and the making of splints and many similar things which any one is liable to be called upon to do at any time.

## EMPLOYMENT BULLETIN

**Note: In Sending applications stamps should be enclosed for forwarding.**

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 12th of the month.

### POSITIONS AVAILABLE

041 Mechanical engineer for manufacturing plant employing 1200 men. Thorough technical training, some experience in machine shop work and experience in executive capacity. Location Massachusetts.

042 Concern manufacturing small electrical motors in quantities wants draftsman or clerk experienced in the standardization of product parts as well as tools; must be familiar with drafting room organization and systematic recording of standards. State age, references and salary. Name confidential, apply by letter.

043 Chief engineer charge of power plants and equipment, including four or five power houses, boiler plant, electric power station, etc. Location Delaware.

046 Mechanical engineer, experienced in soap factory construction and management, for position in vicinity of New York. Name confidential.

047 Four first-class, highly efficient engineers; the minimum salary, $150 and expenses; positions will necessitate the men being on the road approximately seventy-five per cent of the time. Work consists of making power plant examinations, investigations, boiler tests, reports and recommendations. Prefer men with college education if possible, pleasant personality and tactful, as there will be constant call to handle difficult situations. Applicants must be familiar with boiler room economics and able to handle and conduct boiler tests, instructing the local men in such a way as to place the plant on the highest possible base of efficiency.

053 Young engineer in power plant work, steam engineering, and testing, for position with New Jersey concern.

054 Three draftsmen for service with a large mining company in Chili, South America. Two men must be first-class designers familiar with layout and detail work connected with a large milling and smelting plant. Third good steel designer. Must be unmarried and sign an agreement for three years. Salary starts day of departure from New York and all expenses paid to Chili and return. Living conditions at the plant are very good; climate temperate, pleasant and healthful. In application state age, experience, references and salary expected.

056 Firm of engineers and contractors having offices in New York and Chicago desires to add to present line agency for turbine or similar equipment.

061 Mechanical engineer for shop in middle west. Must have had practical shop experience and understand general machinery repairs, knowledge of boilers and engines and proper speeds and feeds of machine tools; also some knowledge of dies for pressing hot work. State age, experience, reference and salary.

### MEN AVAILABLE

C-1 Associate-member, graduate engineer, six years teaching and four years general engineering experience desires position for the coming academic year in mechanical department of a technical school.

C-2 Junior, Stevens graduate, age 30, six years experience, desires position with contracting or constructing engineering firm, consulting engineer or architect.

C-3 Associate-member, technical graduate with broad experience in foundry, pattern shop, machine shop, drawing office and design, desires position of responsibility along similar lines. At present designing engineer for large machine tool concern. Eastern location preferred.

C-4 Member, age 39, married, with broad and thorough manufacturing experience from apprentice to agency manager in a large engineering corporation manufacturing steam and producer gas engines, producers and transmission machinery; with firm for nine years in the capacity of draftsman, designer, estimator, mechanical engineer, salesman and agency manager, also experienced in efficiency engineering, correspondent and advertising, desires position.

C-5 Junior member, technical graduate, 13 years railroad experience in motive power department as machinist, draftsman, boiler inspector, machine shop, car, roundhouse and general foreman, desires position as master mechanic or mechanical engineer.

C-6 Mechanical engineer with broad and varied experience available as purchasing engineer or as technical assistant in purchasing office.

C-7 Member, technical graduate, 12 years experience as designer, assistant superintendent and sales engineer with three well known engine building concerns, would consider responsible position with large engineering firm. At present employed.

C-8 Junior, graduate, broad experience in concrete materials, three years highway experience, now leveler, wishes position in foreign country.

C-9 Mechanical engineer, age 37, Stevens graduate 1900, experienced and resourceful, at present mechanical superintendent and assistant manager of large manufacturing plant desires position.

C-10 Member, technical graduate, wide training and experience in design of power plants and machinery, construction, maintenance and operation, purchasing engineering material, executive charge of all consulting engineering work, including building construction of all kinds, desires position as works manager or superintendent.

C-11 Junior, mechanical engineer, M. I. T. graduate, five years manufacturing experience, at present superintendent and purchasing agent of small concern, desires similar position in East with large firm preferably metal drawing and stamping.

C-12 Graduate engineer, six years experience factory maintenance and equipment work, desires position.

C-13 Member, technical graduate, with extended and unusual experience in shop, factory and power plant design, construction, equipment and operation, desires connection with high grade concern where the requirements call for engineer of ability and experience.

C-14 Junior, technical graduate in mechanical and electrical engineering, ten years experience in design, construction, operation and maintenance of power house and substations, high voltage electric design, piping design and layouts, etc., and building designs, desires position as power engineer, assistant superintendent of large mill, or designing engineer for large engineering firm or contractor.

C-15 Superintendent familiar with latest methods in machine shops and manufacturing plants, capable of demonstrating the output of machine tools and other equipment and getting the maximum production, can design tools and devise methods of producing interchangeable work at low cost.

C-16 Technical graduate, age 32, ten years experience factory engineering, including estimating, drafting, planning and economical production through cost control, desires position as superintendent, assistant to manager or factory engineer.

C-17 Superintendent or assistant, 11 years experience in executive capacity; thoroughly conversant with modern machine shop methods, expert designer of tools and labor saving devices. Exceptional experience in planning economical methods and qualified to handle manufacturing problems to increase production. Expert in pressed steel and punch press work.

C-18 Engineer, Stevens graduate, age 31, unmarried, capable manager, excellent designer, experienced writer of specifications, has just completed supervision of several large manufacturing plants, desires position as chief engineer for firm of industrial engineers and architects. Especially familiar with South, location immaterial.

C-19 Man with tool room and designing experience and familiar with metal working machine tools, special machinery for quantity production, tin can and paper container manufacture, is open for a position in the middle west. Can offer an improved design of a medium sized machine for manufacture.

C-20 Associate-member, technical education, age 31, experienced in shop, drawing room, as erecting foreman, has had charge of engine and boiler tests and with experience as tool designer on small work, desires position with consulting engineer or as salesman. Salary secondary consideration. Location immaterial.

C-21 Junior member, age 29, married, 12 years experience in design and construction of Diesel oil engines (European type), high grade automobile machinery and industrial plants, desires position.

C-22 Member, age 34, M. I. T. graduate, married, for past six years with leading engineers and architects in the East, designing steam power plants, heating and other piping systems and inspecting construction and equipment, at present employed as superintendent on construction and equipment of large mill and power plant, desires position along similar lines.

C-23 Member, age 33, with wide experience in design and construction of railway equipment, including modern steel passenger cars and trucks for heavy electric traction, desires position as assistant chief engineer or in similar capacity in charge of design or construction work along similar lines.

C-24 Junior member, University of Michigan graduate in mechanical and electrical engineering, age 29, unusual experience in efficiency work and design. Has held positions as superintendent, manager, efficiency engineer, and in charge of design. Some sales experience.

C-25 Junior, Cornell graduate, age 25, two years experience in fuel engineering and boiler testing, desires position in testing or experimental department of engineering concern. At present employed.

C-26 Member, graduate engineer with wide experience in efficiency engineering, also design and superintendence of light, heat and power plants, desires position with consulting engineer, architect or private concern. At present employed.

C-27 Member, graduate mechanical engineer, age 39, 20 years experience various engineering fields, inventive and executive ability, at present treasurer and general manager of engineering concern, desires to connect with responsible concern.

C-28 Member, technical graduate with 16 years railroad experience in motive power department as machinist, draftsman and mechanical engineer, desires similar position, or one as assistant superintendent, assistant superintendent of motive power, or motive power assistant to general manager or vice-president. Location immaterial.

C-29 M. I. T. graduate in mechanical and electrical engineering, age 32, married, broad and practical experience in power plants, locomotive repair shops and textile mills. Experience and ability could be applied in organization requiring man for chief engineer, production manager, electrical-mechanical or efficiency engineer, or for similar productive position.

C-30 Junior member, age 28, graduate mechanical engineer, five years practical experience, last two and one half years engineer of tests of large automobile company, desires position as assistant superintendent or engineer.

C-31 Mechanical and electrical engineer, 14 years experience in power plant and factory engineering, operation, maintenance and appraisal, also in handling men, systematic and economical operation, purchasing of equipment and material, recent experience in rubber and chemical works, desires position as works manager or supervising engineer of a manufacturing or industrial plant.

C-32 Junior, age 38, sales engineer, broad experience in handling high grade mechanical specialties, acquaintance in manufacturing and engineering fields, desires to represent manufacturers in east and middle west. At present employed.

C-33 Member, graduate M. I. T. in mechanical engineering, age 39, married, experienced in manufacture of ordnance-rifled arms, shell and ammunition, design and construction of drydocks—wood, stone and floating, pumping plants, power houses and shops; acid and electrolytic refineries; wire and cable plants; reinforced concrete and general building construction with complete electrical and mechanical equipment for same; nine years general and seven years consulting engineering; position to be executive, superintendent or engineer of construction. Location preferred, Eastern Canada.

C-34 Junior, graduate mechanical engineer, age 26, over four years experience in power machinery and power station work including general inspection work on large hydro-electric power house construction; familiar with reinforced concrete and structural steel construction; considerable experience as draftsman, desires position on plant layout work or in the field. Location immaterial.

C-35 Lehigh University graduate in mechanical engineering, three years experience in design, shop work, superintending, construction and installation; can produce results at handling men, now maintenance engineer of factory employing 800, desires position with manufacturing, engineering, consulting or contracting firm.

C-36 Mechanical engineer, age 29, seven years practical experience in designing and drawing up specifications, also assistant engineer in superintending construction of power plants, water works, etc., desires position. At present employed.

C-37 Graduate M. I. T. in mechanical engineering, two years experience in maintenance of power equipment, plant and designing new factory building with large manufacturing concern, two years inspecting reinforced concrete and steel structures with irrigation project, familiar with reinforced concrete design, desires position with construction firm, or power and plant department of manufacturing concern.

C-38 Associate, age 33, college and technical education, seven years experience in charge of engineering correspondence and estimating, desires position as assistant to consulting engineer or to executive of corporation with good chance for advancement. Location New York or vicinity.

C-39 Graduate mechanical and electrical engineer, experienced in design and construction of machinery, building, manufacturing, systematizing, accounting, refrigeration, desires position in New York.

C-40 Member, sales engineer located in New York, good correspondent and estimator, broad acquaintance in manufacturing, engineering and expert field, has handled successfully well known accounts in New England and Eastern States, desires to negotiate with manufacturer wishing a reliable representative in New York who will accept the responsibility for the management and results.

## ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Sewerage Practice. Vol. 1—Design of Sewers, Leonard Metcalf and H. P. Eddy. *New York, 1914.*

Automobiles Industriels Avant-Train Latil. Gift of Mission Française l'Ingenieurs aux Etats Unis.

Carnegie Endowment for International Peace. Report of the International Commission to inquire into the Causes and Conduct of the Balkan Wars. *Washington, 1914.* Gift of C. W. Rice.

The Cost of Power, G. B. Gould and C. W. Hubbard. *New York, 1914.* Gift of authors.

Das Eisenbahnwesen der Schweiz, Placid Weissenbach. Band 2. *Zürich, 1914.*

Etude sur les Vehicules Automobiles a Quatre roues motrices, Charles Blum. *Paris, 1913.* Gift of Mission Française l'Ingenieurs aux Etats Unis.

Firearms in American History, C. W. Sawyer. Vol. II —The Revolver. *Boston, 1911.*

Die Grundgleichungen der Mechanik, A. E. Haas. *Leipzig, 1914.*

Handbook of Construction Plant, Its Cost and Efficiency, R. T. Dana. *Chicago, 1914.*

Hawaiian Volcano Observatory. Weekly Bulletins. vol. 2, no. 28-30. *1914.* Gift of C. W. Rice.

Heat Treatment of Steel. *New York, 1914.*

High-Power Gas Engines, H. Dubbel, translated from the German by F. Weinreb. *New York, 1914.*

Industrial Plants. vol. 2. Gift of Chas. T. Main.

An Introduction to the Mathematical Theory of Heat Conduction with Engineering and Geological Applications, L. R. Ingersoll and O. J. Zobel. *Boston, 1913.*

Die Kolbenpumpen einschliesslich der Flügel und Rotationspumpen, H. Berg. *Berlin, 1914.*

Lake Ship Yard Methods of Steel Ship Construction, Robert Curr. *Cleveland, 1907.*

Leland Stanford Junior University. Register, 1913-14. *1914.* Gift of A.S.M.E.

Das Maschinen-Zeichnen, A. Riedler. Ed. 2. *Berlin, 1913.*

National Association of State Universities in the United States of America. Transactions and Proceedings, 1914. *Burlington, Vt., 1914.* Gift of Free Press Printing Co.

Organ für die Fortschritte des Eisenbahnwesens. Fünfzehnter Erganzungsband. Zweckmässigkeit und Wirtschaftlichkeit des Eisenbetons. *Wiesbaden, 1914.*

Permeability Tests on Gravel Concrete, made at the Materials Testing Laboratory of the University of Wisconsin, M. O. Withey. Reprinted from Journal of the Western Society of Engineers, Nov. 1914. Gift of author.

Poor's Manual of Railroads, 1915. *New York, 1915.*

Sherman, James Schoolcraft. Memorial Addresses delivered at a joint session of the Senate and the House of Representatives of the U. S., Feb. 15, 1913. *Washington, 1913.* Gift of U. S. Senate.

Steam Turbines, J. A. Moyer. Ed. 2. *New York, 1914.*

Die Steuerungen der Verbrennungskraftmaschinen, Julius Magg. *Berlin, 1914.*

Technische Messungen bei Maschinenuntersuchungen und im Betriebe, A. Gramberg. Ed. 3. *Berlin, 1914.*

Universal Safety Standards, Carl M. Hansen. Ed. 2. *New York, Universal Safety Standards Publishing Co., 1914.* Gift of publishers.

The first of a series of handbooks compiled by Mr. Hansen under the auspices of the Workmen's Compensation Service Bureau of New York. It is devoted to the safeguarding of machine shops, not the "why" of safeguarding, but the "how." Safety devices are not only described, but illustrated by numerous plates, the safeguarding appliance being shown in the safety color, green. Safety appliances for the foundry are also shown.

The great interest in these appliances, due partly to humanitarian considerations and partly to workmen's compensation legislation, is reflected in the great number of appliances pictured and described.

W. P. C.

Verein Deutscher Ingenieure. Das neue Vereinshaus in Berlin, 1914. Gift of Verein deutscher Ingenieure.

GIFT OF WM. P. GERHARD

The Port of Los Angeles. Nov. 1, 1913.

The Underground Haulage of Coal by Wire Ropes, Wilhelm Hildenbrand. *Trenton, 1903.*

Eisenbahn-Bauwesen, A. T. Susemihl und E. Schubert. Ed. 6. *Wiesbaden, 1899.*

GIFT OF ENGINEERING RECORD

American Highway Association. Proceedings of the American Road Congress. Pt. II. *Atlantic City, 1912.*

American Society for Testing Materials Reports of the Committee on Preservative Coatings for Structural Materials, 1903-13.

American Society of Municipal Improvements. Proceedings 16th Annual Convention, 1909. *Milwaukee, 1909.*

Ballard, W. E. Builders' Quantities. *Lond-N. Y., 1913.*

Baltimore. Sewerage Commission. Annual Report, 1906, 1908, 1910-12. *Baltimore, 1907, 1909, 1911-13.*

Gillmore, Q. A. Practical Treatise on Roads, Streets and Pavements. Ed. 6. *N. Y., 1888.*

Johnson, G. A. Pure and Wholesome Water.

Judson, W. P. Road Preservation and Dust Prevention. *N.Y.-Lond., 1908.*

——— City Roads and Pavements. Ed. 3. *N. Y.-Lond., 1906.*

Monfort, W. F. Water Supply of St. Louis. Reprinted from Report of Water Commissioner, Jan., 1913.

National District Heating Association. Proceedings of 5th Annual Convention, 1913.

New York. Metropolitan Sewerage Commission. *Report 1914.*

New York State. State Commission of Highways. *Report 1912.*

Ontario. Public Roads and Highways Commission. *Report 1914.*

Panama-Pacific International Exposition. Universal Exposition, 1915. Rules and regulations. *San Francisco, 1915.*

Philadelphia. Department of Public Works. *Annual Report 1912.*

Ricketts, P. C. History of Rensselaer Polytechnic Institute 1824-1914.

Rochester (N. Y.). Sewage Disposal System. *Report 1912.*

St. Louis Water Supply. Report to the Board of Public Improvements by the Water Commissioner. *1913.*

Spalding, F. P. Hydraulic Cement. *N. Y. 1897.*

Stoney, B. B. Theory of Strains in Girders, etc. *N. Y. 1873.*

U. S. Agricultural Dept. Yearbook. *1912.*

Warren, F. D. Handbook on Reinforced Concrete. *N. Y. 1906.*

GIFT OF E. W. STERN

Engineering. vols. 60-64. *London, 1895-97.*

Engineering Record. vols. 23-36. *N. Y., 1890-97.*

EXCHANGES

American Society of Heating and Ventilating Engineers. Transactions. vol. 19, 20. *New York, 1913-14.*

——— List of Members, corrected to June 1, 1914. *New York, 1914.*

Industrial Arts Index, 1914. *White Plains, 1914.*

Institution of Automobile Engineers. Proceedings, vol. 8. *Westminster, 1914.*

Institution of Gas Engineers. Transactions, 1914. *London, 1914.*

TRADE CATALOGUES

De Laval Steam Turbine Co. *Trenton, N. J.* De Laval high efficiency centrifugal pumps. "Catalogue B," 1914. Gift of Geo. H. Gibson Co.

Flannery Bolt Co. Pittsburgh, Pa. Staybolts. January, 1915.

Gas Engine & Power Co. and C. L. Seabury & Co. Seabury safety water tube boilers. "Catalogue no. 10."

Koehring Machine Co. *Milwaukee, Wis.* Koehring Mixer. December, 1914-January, 1915.

R. U. V. Company, Inc. *New York City.* Bulletin no. 10. R. U. V. system of sterilization of water by the Ultra Violet Rays.

——— no. 11. Ultra-violet ray sterilization for public water supplies.

——— no. 112. Ultra-violet ray sterilization for swimming pools.

——— no. 113. Ultra-violet ray sterilization for boilers.

——— no. 114. Ultra-violet ray sterilization for hospitals.

Sterilization of water by Ultra-Violet Rays. 29 pp.

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. January, 1915-February, 1915.

GIFT OF AERONAUTICAL SOCIETY

Lavigne ball solderless fittings. Model Aeroplanes. Price list of W. H. Phipps. Timken roller bearings. Dimension sheets Thomas aeroplanes and flying boats. Wittemann aeroplanes, gliders, supplies.

## UNITED ENGINEERING SOCIETY

Bibliographie der fremdsprachigen Zeitschriftenliteratur. F. Dietrich. Band IX, 1913. *Leipzig, 1911.*

Clark Stabilizer. Description. Gift of M. E. Clark.

Engineering Index 1914. *N. Y., 1915.*

Handbuch des Wasserbaues, Hubert Engels. vols. 1-2. *Leipzig-Berlin, 1911.*

International Railroad Master Blacksmiths' Association. Report of Proceedings of 22d Annual Convention, 1914. Gift of Association.

Jahrbuch der Technischen Zeitschriften Literatur. Für die Literaturperiode 1913. *Berlin, 1914.*

Kansas Gas, Water, Electric Light and Street Railway Association. Official Convention Proceedings 13th, 16th, 17th Annual Meeting, 1910, 1913, 1914. Gift of Association.

Das Leuchten der Gase und Dämpfe, Heinrich Konen. (Die Wissenschaft, Band 49). *Braunschweig, 1913.*

Die Methoden der Massanalyse, H. Beckurts. *Braunschweig, 1913.*

Michigan Engineering Society (Formerly Michigan Association of Surveyors and Civil Engineers). Proceedings of Annual Meetings. 1-3, 5, 7-8, 10-16, 19-22, 24-25, 27-34. v. p. 1880-82, 1884, 1886-87, 1889-95, 1898-1901, 1903-04, 1906-14. Gift of Michigan Engineering Society.

New International Encyclopaedia. vols. 7-8. *New York, 1914.*

Pennsylvania. First Industrial Directory, 1913. *Harrisburg, 1914.* Gift of Department of Labor and Industry.

Preservation of Structural Timber, H. F. Weiss. *New York, 1915.*

Prometheus. vols. 1-19, 1889-1908. *Berlin, 1890-1909.*

Red Book. A text book on U. S. gypsum products for architects, contractors, plasterers and U. S. G. dealers. 1914. *Chicago, 1914.* Gift of U. S. Gypsum Company.

Sewerage. The Designing, Construction and Maintenance of Sewerage Systems. A. P. Folwell. ed. 6. *New York, 1914.*

Société Technique de L'Industrie du Gaz. Compte-rendu du Quarantième Congrès, 1913, Toulouse. *Paris, 1913.* Gift of American Gas Institute.

Some Problems in Concrete House Construction, G. S. Mumford. Read at 1st Annual Convention of American Society of Engineers, Architects and Constructors, July 3, 1914. Gift of T. H. Boorman.

Steel Working and Tool Dressing, Warren S. Casterlin. *New York, 1914.*

United States Steel Corporation. 6th-12th Annual Report, 1907-1913. *Hoboken, 1907-13.* Gift of U. S. Steel Corporation.

War Map of American Trade Opportunities, 1914. Gift of Alexander Hamilton Institute.

Waterproofing—Various Applications and Comparative Costs, T. H. Boorman. Reprint from Proceedings of National Association of Cement Users. vol. V, 1909. Gift of author.

What is Wrong with the Telephone, C. S. Goldman. Reprinted from "Nineteenth Century," Aug. 1914. Gift of American Telephone and Telegraph Company.

Wisconsin Industrial Commission. Proposed Building Code. *Madison.* Gift of commission.

Zeitschrift für Kleinbahnen. vol. 1, nos. 1, 3-8; vols. 3-5; vol. 6, nos. 2-12; vols. 7-8. *Berlin, 1894, 1896-1901.*

Zeitschrift für Physikalische Chemie. Band 83-86. *Leipzig, 1913-14.*

EXCHANGES

American Society of Refrigerating Engineers. Transactions vol. IX. *New York, 1914.*

Institution of Civil Engineers. Minutes of Proceedings. vol. 196. *London, 1914.*

Institution of Civil Engineers of Ireland. Transactions vol. XL. *Dublin, 1914.*

Institution of Mechanical Engineers. Proceedings, 1914, pts. 1-2. *London, 1914.*

Institution of Naval Architects. Transactions, vol. LVI. *London, 1914.*

List of References on Water Rights and the Control of Waters. U. S. Library of Congress. *Washington, 1914.*

Manchester Association of Engineers. Transactions, 1913-14. *Manchester, 1914.*

The Shipbuilder. vols. IX, X. *Newcastle-upon-Tyne, 1913-14.*

TRADE CATALOGUES

Atlas Bolt & Screw Co. *Cleveland, O.* A.S.M.E. standard for machine screws and machine screw nuts.

Coen *Co., San Francisco, Cal.* Catalogue no. 1. The "Coen" system of mechanical oil burning, 1914.

Crane, Wm. M. Co., *New York, N. Y.* "Vulcan" gas appliances. Catalogue.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. Oct. 1914.

Goldschmidt Thermit Co. *New York, N. Y.* Thermit insert fully welded rail joint. (Pamphlet no. 39.) Thermit process of pipe welding. (Pamphlet no. 16. ed. 2.)

New York Air Brake Co., *New York, N. Y.* Catalogue of air brake apparatus, September 1913.

Package Machinery Co. *Springfield, Mass.* Automatic machines for better wrapping of products. 31 pp.

Safety Rules. The Metropolitan West Side Elevated Railway, Northwestern Elevated Railroad, South Side Elevated Railroad, Chicago and Oak Park Elevated Railroad. ed. 2. Gift of Northwestern Elevated Railroad Co.

A Statesman's Opportunity. An address before the Railway Business Association, by Fairfax Harrison. *New York, December 10, 1914.* Gift of Fairfax Harrison.

Union Iron Works Co. *San Francisco, Cal.* Liquid fuel mechanical oil-burning system "Dahl" patents. 1913.

Washington Engine Works. *New York, N. Y.* "White" mechanical fuel oil burning system. 31 pp.

Water Terminal and Transfer Facilities. Letter from the Acting Secretary of War. U. S. House of Representatives, 63d Congress, 1st session, document no. 226. *Washington, 1913.* Gift of Thos. G. Patten.

## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

### ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

John A. Brashear, *President*

Calvin W. Rice, *Secretary*

Finance Committee, R. M. Dixon

House Committee, S. D. Collett

Library Committee (to be appointed)

Committee on Meetings, J. H. Barr

Committee on Membership, W. H. Boehm

Publication Committee, C. I. Earll

Public Relations Committee, M. L. Cooke

Research Committee, R. C. Carpenter

Committee on Constitution and By-Laws, Jesse M. Smith

LOCAL MEETINGS

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*Boston:* H. N. Dawes
*Buffalo:* David Bell
*Chicago:* S. G. Neiler
*Cincinnati:* J. B. Stanwood
*Los Angeles:* Walter H. Adams
*Milwaukee:* L. E. Strothman
*Minnesota:* Wm. H. Kavanaugh
*New Haven:* H. B. Sargent
*New York:* Edward Van Winkle
*Philadelphia:* H. E. Ehlers
*San Francisco:* C. R. Weymouth
*St. Louis:* Edward Flad

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal

THE JOURNAL OF

# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 APRIL 1915 Number 4

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## COMING MEETINGS OF THE SOCIETY

*April* 8, *Buffalo, N. Y.* Local Illustrated Meeting. Stereopticon views will be given showing interesting machinery and other views connected with engineering work which is being carried on in Buffalo by local manufacturers.

*April* 8, *Worcester, Mass.* Joint meeting of local members of of the Am. Soc. M. E. with the graduates of Worcester Polytechnic Institute at Hotel Bancroft. Dinner at 7 o'clock followed by a stereopticon lecture on the Submarine, by R. H. M. Robinson, General Manager of the Lake Torpedo Boat Company. A committee for a local section of the Society will be appointed.

*April* 12, *Philadelphia, Pa.* Joint meeting with the American Institute of Electrical Engineers. Papers: Engine Driven vs. Turbine Driven Units in Small Capacities, by Albert C. Wood; and Washing and Cooling Air for Use with Electrical Apparatus, by an author to be announced.

*April* 13, *New York City.* Subject: Modern Electric Elevator and Elevator Problems, by David Linquist, Chief Engineer of Otis Elevator Company.

*April* 21, *New Haven, Conn.* Spring meeting, with afternoon and evening sessions. Subject: The Development of Machine Tools.

*April* 22, *Buffalo,* N. Y. Annual Meeting. Papers: Conservation of Niagara Falls Power, by H. B. Alverson, Superintendent of The Cataract Power & Conduit Company, and Patents, by C. W. Parker of Wilhelm and Parker.

*April* 23, *Boston, Mass.* Joint meeting under the auspices of the American Institute of Electrical Engineers.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 April 1915 Number 4

# THE SPRING MEETING

ARRANGEMENTS are progressing satisfactorily for the coming Spring Meeting which is to be held in Buffalo from the 22nd to the 25th of June. This date follows the commencement season at the colleges, so that many who are connected with the work of the technical schools of the country will be able to attend, where heretofore there could be only a very limited representation from any one college.

The local committees at Buffalo have all been appointed and are at work. The chairmen of these committees are as follows: General Committee, David Bell; Finance, D. W. Sowers; Reception, H. P. Parrock; Entertainment, David C. Howard; Hotel, W. H. Carrier; Printing and Publicity, John Younger. The entire membership of The American Society of Mechanical Engineers in Buffalo are to constitute the Reception Committee. The ladies of Buffalo are to appoint several of their number as patronesses to assist the Entertainment Committee at receptions and entertainments for the visiting ladies.

During the three days of the meeting there will be three periods for professional sessions, with probably four sessions, one of which will be in charge of the local engineers at Buffalo in accordance with the usual custom for the Spring Meeting. The papers for the several sessions are well in hand, the larger part of them already having been received by the Committee on Meetings, who regard them as of a very high order. Definite announcement of these will be made in the May issue of The Journal and printed copies will be available, free of cost, for all members who desire them in advance of the meeting.

This is the first meeting of the Society in Buffalo, although it held its convention at Niagara Falls in 1898. Naturally, Niagara Falls with its tremendous storehouse of energy, attracts the attention of engineers the world over; and especially in the electrical and chemical fields, because of the electro-chemical industries made possible there by the great quantity and low cost of power. The City of Buffalo, however, only 20 miles from Niagara Falls, with a population of 500,000, has many and diversified industries equally as interesting to the mechanical engineer. Raw materials, coal, ores and lumber are brought by boat into Buffalo at minimum cost for transportation; and this, with the transmission of power from Niagara Falls, has made possible the great industrial development of the city.

The manufacturing plants include several large steel works, the largest of which is the Lackawanna Steel plant; blast furnaces, foundries, rolling mills for copper and brass, machine tool plants, machine shops manufacturing Diesel engines, steam pumps, steam engines, elevators, gas and gasoline engines, etc.; automobile plants, the new Curtis factory for aeroplanes, manufactories for paints, oils, varnishes, rubber goods, hardware, paper board, etc. It is also a center for the brewing and flour milling industries.

Buffalo, besides, is a city set in a beautiful country with the added attractions of the lake and of Niagara Falls and is at its best in the month of June. Every opportunity will be afforded for the enjoyment of the city and its surroundings, both by the ladies of the party and the visiting engineers.

## SAN FRANCISCO MEETINGS

Circulars have been sent to the entire membership relating to the International Engineering Congress for 1915 and the special train arrangements which have been provided.

The International Engineering Congress will be held September 20-25, 1915, in San Francisco, under the auspices of the American societies of civil, mining, mechanical, electrical and marine engineers. In connection with the Congress, The American Society of Mechanical Engineers will hold a meeting on September 16 and 17, the latter part of the week immediately preceding the week of the Congress, so as to enable its members to attend both the meeting of their own Society and of the Congress, and to visit the Panama-Pacific Exposition with the least possible expenditure of time.

During this period the headquarters of The American Society of Mechanical Engineers will be at the

Hotel Clift, with the management of which arrangements should be made direct and at as early a date as possible. A special train will leave New York on Thursday, September 9, arriving in San Francisco on Wednesday, September 15, with stops of several hours at Niagara Falls, Colorado Springs and the Grand Canon. Special arrangements are also planned for those in the South to go by way of New Orleans.

## TRIP BY THE SECRETARY

In response to a number of invitations to visit the student engineering societies affiliated with this Society, the Secretary has recently visited Purdue University, Case School of Applied Science, Ohio State University, University of Cincinnati, State University of Kentucky, Virginia Polytechnic Institute, Georgia School of Technology and the Alabama Polytechnic Institute.

The Secretary was particularly pleased to visit Purdue as he had not been able to stop at the University for a number of years. It was not because of lack of interest that no visit had been made, but simply on account of the many demands on the Secretary's time which made more frequent trips impossible. On account of the prominent position which the University takes in research work, particularly in railroad engineering, which is one of the branches of engineering in which the Society takes great interest, there should be a strong section of the Society here and also an active student engineering society. The Secretary was particularly pleased to see on the bulletin boards an announcement of a joint meeting between the student societies of the Mechanical Engineers and of the Electrical Engineers. It is this spirit of coöperation which gives America its preëminence in the world in all activities. It is in this way that, while maintaining commendable rivalry, we omit competitive meetings.

At the University of Cincinnati splendid interest was shown. The men of the engineering society have to meet in the evening and, on account of being in the shops part of the time, the entire section could not meet on the same evening; consequently, the Secretary arranged to meet the students on two different evenings in order to greet them all. A photograph was taken of the members of the section and the section was encouraged to send it to the Society so that a reproduction of it might be given in The Journal.

The members of the Society in Cincinnati and vicinity had a dinner preceding the address in regard to the Society's work which was attended by Mr. Edward Hedden Worthington, a grandson of Henry R. Worthington, the founder of the Society, and also by George Hornung who has been a member of the Society for 30 years.

One of the interesting features in connection with the meeting in Cincinnati was the visit to the rooms of the Engineers Club. Previous to the organization of local sections, the Engineers Club was practically inactive. At no time had as many as 15 of our members been members of the Club. As it is the policy of this Society to encourage in all cities the local engineering society and to make it the center of life for the engineering profession in that locality and to make the branches of the national societies contribute to the success of the local society, it was a source of great satisfaction to learn that Cincinnati had literally carried out the advice of the Society and had revived the Engineers Club with the result that there are now several hundred members, with 50 from our Society active in the organization, and with comfortable rooms in the center of the city open and available from early until late every day in the year.

At the State University of Kentucky, the Society enjoys the unique situation of having every Junior and Senior student in engineering a member of the student engineering society affiliated with The American Society of Mechanical Engineers. The mottos in the office of the dean are indicative of the theme of the address of the Secretary, namely, that the benefits for membership in the Society and in the student engineering societies are in proportion to the investment made by the student.

At Columbus splendid enthusiasm was shown by the men. Our student engineering society has as its officers the leaders in the college athletics and the same merit system prevails with regard to officers of sections as is required in athletics, namely, that no man may be an officer of a section with any demerits in the work of the University.

The Secretary does not want to fail to note the admirable library at Columbus and the enthusiasm of the assistant librarian to carry out the scheme proposed by the librarian of the Engineering Societies, to coöperate in the preparation of a finding list of engineering literature so that students and members in research work will be able to learn in what libraries they can secure sets of periodicals, Transactions and the important works generally.

At the Virginia Polytechnic Institute, Blacksburg, West Virginia, the Secretary was greeted by large posters announcing the meeting of the Society, distributed about the town. The meeting was attended by the entire student body and citizens generally. In the afternoon, the Secretary gave a separate address to the student branch. It was gratifying to have Dean Randolph state that six months after graduation he had joined the Society and that he had now been a member for 31 years and considered it the best investment of his life and a source of continual benefit. It should be remarked in this connection that, notwithstanding the fact that Blacksburg is a little out of the main line, when the interest of the members was aroused recently in the matter of bringing the benefits of membership in the Society to the attention of the engineering pro-

fession, Dean Randolph was successful in reaching a larger number than any other individual member.

At the Alabama Polytechnic Institute, Auburn, the Secretary was given the honor of addressing the entire student body in the presence of the President and the faculty. This was followed in the afternoon by a special address to the engineering students which was so well attended that the audience room was filled to overflowing and men were standing in the halls.

At the Georgia School of Technology similar enthusiasm was shown in the address given in the forenoon before the student body, which was followed by an address in the evening before the affiliated technical societies. A number of the students attended the evening meeting paying $1.00 for the privilege as refreshments were served in connection with the meeting, and notwithstanding that there were three other student engagements scheduled for that evening.

In most places the merit system prevails and the work of the student engineering societies is being conducted on a high plane, direct or indirect credit in the regular school work being given for work in the student branch.

In each city where there are local members a meeting was also arranged. Great enthusiasm was shown, particularly at the universities in the South and at the meeting of the affiliated technical societies in Atlanta. The theme of the Secretary's remarks was the participation of the engineer in public affairs and involved a statement of what the engineer is doing and an encouragement to the engineers to take a great part from a sense of public duty and public service; also, that it is incumbent upon the engineer to acquaint the public with the work of the engineer. Following further statements about the work of the Society and its activities, there was an address illustrated by stereoptican views of the trip of the Society through Germany two years ago, with a description of the Deutsches Museum.

At Atlanta, members of the four national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers, and the American Chemical Society and the Engineering Society of the South have effected an organization where special emphasis is placed on service to the public, and in this respect so far as the Secretary is advised, this feature is unique in American engineering societies and highly to be commended. In other cities the engineers have gotten together in a splendid way, notably in St. Louis and Boston, where all meetings are coöperative; but in Atlanta they not only have coöperative meetings but, without any desire for position or remuneration, are placing themselves at the disposal of the city administration and in fact insisting on efficient, intelligent work being performed in the matter of smoke abatement, street construction, sewers and garbage disposal, water works, etc., which is obviously the peculiar field of the engineer. In too many cities positions in these departments are filled by men with no peculiar fitness for the work.

## HESS PRIZES FOR JUNIOR AND STUDENT MEMBERS

Announcement has already been made in The Journal and Year Book of the generous gift of Mr. Henry Hess, by which the income from $2000 is available for the awarding of prizes for technical papers from Junior and Student Members. The committees of award for these prizes for the coming year have been appointed by the Council, and consist of the following members:

| *Junior Prizes* | *Student Prizes* |
|---|---|
| R. H. Fernald | F. R. Hutton |
| Fred E. Rogers | R. H. Fernald |
| George B. Brand | D. S. Kimball |

A statement is made in the first pages of this number of The Journal of the conditions governing the award of prizes and it is hoped that every Junior and Student Member will read these with care and that all who have valuable material which is available for a contribution to the Society will respond to the call and join in the friendly contest by sending such contributions to the Secretary of the Society so that they will be received on or before June 30, 1915.

## COUNCIL NOTES

At the meeting of the Council on March 12, 1915, it was voted to approve the following amendment to the By-Laws:

All written reports of all committees shall be presented to the Council. Each written report of every committee must be approved in writing by at least a majority of the members of that committee, before it is presented to the Council. A member of a committee who disagrees with the action of a majority of that committee may express his disagreement over his signature either on the report of the committee or in a minority report. The minority report of any member of a committee, if offered, shall be presented at the same time that the report of that committee is presented to the Council.

All reports of committees must be first received by the Council who shall prescribe the manner in which they shall be presented to the Membership of the Society and be made public and printed.

It was voted that the portion of the Boiler Code report entitled "Rules for the Construction of Stationary Boilers and for Allowable Working Pressures," already received by the Council, be copyrighted as a preprint of Transactions. It was voted, also, that under the So-

ciety's copyright and without compensation to the Society, any legislative body be permitted to print these Rules and distribute officially for the state or municipality over its name.

It was voted that the members of the Council be requested to formulate suggestions for the conduct of professional committees and submit them to Mr. Henry Hess as Chairman of the Engineering Standards Committee, that this committee may have the suggestions in hand for drafting its code of rules.

The Secretary read the following resolution from the meeting of the New York Section held February 9, 1915:

"It is recommended that the Council be asked to appoint a committee to consider the question of the Society undertaking a digest of the material that has appeared in the publications of the Society."

In this connection, a communication from the American Gas Institute was presented requesting coöperation in the matter of a joint committee to obtain a standard system of classification of engineering knowledge.

Voted: that the President appoint a committee of five to confer with the Committee of the American Gas Institute and that this committee of the Society also take under consideration the matter of a proposed digest of material that has appeared in the publications of the Society as suggested by the New York section.

Voted: that R. H. Fernald, Fred E. Rogers and George B. Brand be appointed a committee on the Hess Prize for Junior Members and that F. R. Hutton, R. H. Fernald and D. S. Kimball be appointed a committee on the Hess Prize for Student Members.

Calvin W. Rice, *Secretary*.

## PRICE OF THE BOILER CODE

Since the last number of The Journal, in which was chronicled the completion of the report of the Boiler Code Committee on "Rules for Construction of Stationary Boilers and for Allowable Working Pressures," important action has been taken by the Society with regard to the price to be charged for the Boiler Code and in providing for the use of large editions by the legislative bodies of states and municipalities. The original price charged for copies of the Code was $1.00 to members and $1.50 to non-members. It had been thought that in view of the great amount of work that had been expended on the Code, not only by the Committee members but also by the office staff of the Society; and because of the great expense to which the Society had been in printing and handling the preliminary reports of the Committee (approximately $6000), these prices were equitable and reasonable.

It is generally recognized, however, that the primary object of this report is not to reimburse the Society; on the contrary, the report has been prepared for the public good and it is undoubtedly destined to accomplish this end to a greater extent than any other publication which the Society has issued. Its greatest usefulness will not be attained until it becomes a standard in general use throughout the country, and the Society desires to do its utmost to bring about this most desirable accomplishment. It has therefore been decided to establish a scale of prices which shall not only be equitable to the membership of the Society, but attractive as well to legislative bodies.

For sales in limited numbers the same rate will be charged as for all of the reprints issued in pamphlet form by the Society, namely 5 cents per sixteen pages or fraction thereof, to members, and 10 cents to non-members, making the cost of the Code 40 cents to members and 80 cents to non-members on individual orders. For large editions for the use of legislative bodies and municipalities the price has been placed low enough to make it an inducement for ordering direct from the Society rather than to have it reprinted elsewhere, for one of the most important factors to be considered in the introduction of the Code is its accuracy. If the various legislative bodies that use the Code should have it printed by different printing establishments, with non-technical and indifferent proofreading, errors would be certain to creep in; while, on the other hand, any arrangement which would make possible the reproduction direct from the Society's type-plates of special editions that might be desired would insure accuracy. Hence the decision to name a price so low for quantity orders that printing from anything else than the Society's plates would in all probability be precluded. As a result the following schedule of prices has been put into effect:

PRICE LIST

For copies of the "Rules for the Construction of Stationary Boilers and for Allowable Pressures."

20 cents per copy in lots of 2000 or over.
30 cents per copy in lots of 1000 to 2000.
F.O.B. Printer, Lyons, N. Y.
40 cents per copy in lots less than 1000, delivered, to members of the Society (and to organizations when shipped to one address).
80 cents for individual orders delivered to non-members of the Society.
Special covers extra on orders of less than 2000.

An important decision in the administration of the Boiler Code was the action of the Council of the Society at its meeting of March 12, to copyright the Code as a reprint of Transactions. This was the result of a desire to protect the Code from undignified usage or inaccurate reproduction, it having been felt that such protection could not be gained in any other way. It was not the purpose, however, to restrict its distribution or limit its usefulness in the direction for which it was primarily intended. In order that legislative bodies might not be limited in any way by the copyright or in fact any restriction be placed on its distribution, a resolution was passed at the same meeting of the Council, as follows:

*Resolved:* that under the Society's copyright and without compensation to the Society, any legislative body should be permitted to print these Rules and to distribute them officially for the state or municipality over its name.

The completion of the report of the Boiler Code Committee, referred to in the preceding issue of The Journal, marked the inauguration of concerted efforts on the part of organizations of boiler manufacturers and others interested in uniform legislation, looking toward the introduction of the Boiler Code in various states. As announced in that issue, definite steps have been taken in this direction in Wisconsin, Indiana and Ohio. Since then similar action has been taken or proposed in a number of other states, including Michigan, Florida, Pennsylvania, New Jersey, Tennessee, and others. It is also of interest to note the commendatory action of the American Society of Agricultural Engineers at its recent annual meeting with respect to the Code, as evidenced in the following resolutions:

*Resolved:* that we, the American Society of Agricultural Engineers, assembled in annual meeting, do hereby unanimously approve of the efforts of the American Society of Mechanical Engineers to formulate a code of rules for the construction of steam boilers that may be used as a model by legislative bodies and thus promote uniformity.

*Resolved:* that we unanimously recommend the adoption of these uniform rules by the various states and municipalities having boiler legislation pending.

## VISITS BY DELEGATIONS FROM TECHNICAL COLLEGES

At this time of the year, the Society is privileged to receive visits from colleges of groups of students who are en tour for the inspection of various plants previous to the Commencement exercises which come later in the season. Several such delegations have already called and others are expected for the current year.

One of the largest groups which has visited the Engineering Societies Building and Library is the Senior Class of electrical and mechanical engineers from the Sheffield Scientific School of Yale University. There were 120 students, each with his note-book for recording data connected with his trip. To this group, the librarian explained the manner in which the Library of the United Engineering Societies is endeavoring to serve the engineering public in all parts of this country, and even in other countries, by reference work, the translation of articles, and photographic reproduction of articles where complete transcripts are desired.

After inspecting the headquarters of the three founder societies in the building, the students all gathered in the auditorium for brief addresses by the secretaries of these societies, who spoke of the new and broader vision for the engineer who must in this day not only consider himself an engineer of things but of men; and in so doing have in mind that the greatest results can be secured only by providing the best possible conditions for the workers who may come under their control and by giving their own services freely for the public good—in short, that service is the keynote of the success of the present day engineer.

## FREDERICK WINSLOW TAYLOR

Frederick Winslow Taylor, Past-President of The American Society of Mechanical Engineers, died suddenly of pneumonia, in Philadelphia, on March 21.

Mr. Taylor was born in Germantown, Pa., in 1856. He had two years' schooling in Germany and France, and partially prepared for Harvard at Phillips Exeter Academy; but his eyesight became impaired and he had to withdraw from school. He determined, however, to get his education in another way and began an apprenticeship with William Sellers and Company, Philadelphia. In order to make as rapid progress as possible and to get some special advantages, he worked for less pay than the other apprentices, and in four years completed a journeyman's course both in the patternmaker's and the machinist's trade. When he finished his apprenticeship in 1878, times were so dull that he was unable to get work at either of his trades, and he entered the machine shop of the Midvale Steel Company as a laborer.

His first promotion was to the position of shop clerk, after which he was given charge of the toolroom. As head of the toolroom he saw the advantage of having all the shop tools ground by one man and instituted this reform, inventing the Taylor grinder for the purpose. From head of the toolroom he became successively gang boss, assistant foreman and then foreman of the machine shop. Next he became master mechanic in charge of repairs and maintenance of the works; then chief draftsman, and in 1884, chief engineer of the works, thus having advanced from laborer to chief engineer in six years.

Soon after he entered Midvale, young Taylor began to feel the need of a better understanding of the underlying principles of the science of engineering, and in 1880, while working ten hours a day, he began to study at night the engineering course of Stevens Institute of Technology, which he completed in 1883, when he received the degree of M.E. This remarkable accomplishment of passing the examinations of such a course as that of Stevens Institute of Technology in the short period of three years, with practically no assistance from any teacher, and while regularly at work, is striking evidence of his superior ability and capacity.

Mr. Taylor remained with the Midvale Steel Company until 1890, during which time he made many improvements in machinery and methods, and filled in a satisfactory manner the successive positions assigned to him. In his passage through the shops he had

studied the management and methods, and had developed his naturally keen powers of observation and ability to analyze and draw deductions. Whenever possible he made direct application of his deductions until the plant as a whole bore the imprint of his labor.

As no definite data were available as to what a mechanic should produce with a given tool and a given piece of work, he began systematic studies of the subject with the coöperation of the shop men, and as a result the output of many tools was increased 200 to 300 per cent with an increase of pay of 25 to 100 per cent to the workmen. Thus during this time he carefully observed and studied the general problem of securing higher labor and tool efficiencies and laid the foundation of what later became his specialty, "The development and application of the science of shop organization and management."

Frederick Winslow Taylor

His work in constructive engineering was no less remarkable, for he designed the great steam hammer of the Midvale Steel Company, which was the largest successful hammer ever built in the United States, and the one steam hammer in all the world that could yield to the strain of a foul blow and by its elasticity recover its proper alignment.

In 1890 he left the Midvale Steel Company and became manager of The Manufacturing Investment Company, operating large paper mills in Maine, where he remained until his three year contract expired.

He then began, as consulting engineer, to introduce his principles of organization and management into various establishments about the country. During this period and in connection with this work he made many valuable improvements and inventions, a large number of which he patented.

In 1898 the Bethlehem Steel Company found that the output of their forge was much greater than the capacity of their machine shop to handle it. It was estimated that a new machine shop of sufficient capacity to keep up with the forge would cost one million dollars. At this juncture Mr. Taylor's success in producing increased shop efficiencies at other plants led the company to retain him to work at their problem.

Among the experiments made to increase the machine shop efficiency of the Bethlehem Steel Company were those on tool steel in conjunction with Mr. Maunsel White, leading to the discovery of the Taylor-White process of heat treatment, which increased the cutting capacity of tool steel 200 to 300 per cent. This process, and the tools treated by it, are now used in almost every machine shop in this country and abroad. They have revolutionized machine shop practice, and caused many radical changes in the machine tool industry. In the Bethlehem Steel Company's machine shop, where the discovery was made, the use of treated steel and the improved shop methods of Mr. Taylor resulted in such a remarkable increase in production that instead of an increase in the machine shop, an increase in the forge was necessary.

It was during his connection with the Bethlehem Steel Company that Mr. Taylor's ideas took concrete form on a large scale, and it is probable that during that time he first recognized the great possibilities of the broader application of the principles according to which he had been working, and realized the results that would be attained if these principles should become generally adopted throughout our industries. Having grasped the tremendous importance of this subject, Mr. Taylor decided, on leaving the Bethlehem Steel Company, to devote the remainder of his life to expounding these principles, which he now saw would create a new era in the industrial world.

He believed that he could do this to best advantage if he should make no charge for his work; and, having acquired a competency, he gave his services during the last fourteen years free to anybody who was sincerely desirous of carrying out his methods. He did more than this, for he not only invited everybody interested to his home, where he explained his methods to hundreds, and perhaps thousands, of people; but made extensive journeys at his own expense to lecture before interested bodies of people. It was on one of these trips that he caught the cold which resulted in his death.

Thus his work became known and appreciated not only all over this country, but in Europe and as far

as Japan. His books have been printed in almost all civilized countries, including Japan and China.

Although his qualities as an engineer command the admiration of all, his attributes as a man were quite as remarkable, and those who knew him best prized him even more as a man than as an engineer. His friends were quite as numerous among the workmen he came in contact with, as among his social equals; and those who had most to do with him freely testify to the benefit they received from his training and methods. Especially is this true with young men who have worked under him, and his success with them has been due to the fact that while an uncompromising and strenuous taskmaster, he recognized the value of time as an element in training, and was able to overlook the frequent personal issues which those who did not understand his methods insisted in raising at every turn. His remarkable ability to look beyond such issues and to see in them only incidents in the operation of broadening a man's view of work and duties, caused those who worked under him and understood his ideals to regard him as a friend who was always ready to give to his assistants full credit for their work.

He was Vice-President of The American Society of Mechanical Engineers in 1904 and 1905, and President in 1906, when he gave, as his presidential address, his exhaustive monograph, "On the Art of Cutting Metals," a treatise of 250 pages. Later he received the degree of Sc.D. from the University of Pennsylvania.

His written contributions were many; one of the earliest to come before the Society was his "Notes on Belting," presented in 1893. This paper contained the results of a long series of practical tests, and settled many contentions regarding the use and care of belts.

In 1895, he presented his paper on "A Piece-Rate System," in which he expounded the principles on which his system of management was subsequently based.

In 1903, he presented his celebrated paper on "Shop Management," in which he explained his methods in detail and the results to be derived from them.

In 1911, he published "The Principles of Scientific Management," which rounded out his theory of management.

He was joint author with Sanford E. Thompson of two works on concrete, "A Treatise on Concrete, Plain and Reinforced," and "Concrete Costs."

The funeral services for Dr. Taylor were held at the residence of his brother-in-law, Clarence M. Clark, Queen Lane Station, Philadelphia, when brief remarks of appreciation were made by James M. Dodge, Past-President, and Morris L. Cooke, Manager of the Society. The life and work of Dr. Taylor have received extended notice, both in the daily and technical press, and through the written comments of personal friends. Extracts from the remarks by Dr. Dodge and Mr. Cooke, and comments from other sources follow.

### REMARKS BY JAMES M. DODGE

Dr. Frederick Winslow Taylor was a prophet, with honor in his own country and, at the same time, honored and respected in every civilized country of the globe. He was a remarkable student, a devoted husband, faithful friend, an inventor of the first rank, an engineer of resource, knowledge and keen perception, indefatigable in his work, unswerving in his devotion to truth, modest and considerate. With this remarkable combination of temperament and learning he became the bearer of a message that is destined to make him recognized the world over as the emancipator of the worker and the employer; delivering the worker from the oppressive burdens of the old order and granting him freedom to do his best for himself and his family; and his employer from the necessity of being only the taskmaster and granting him freedom and opportunity to be the friend and co-worker of those associated with him.

Through his scientific investigations of the relations between employer and employee he was able to formulate a system which made it possible for both parties to realize that their interests, instead of being in irreconcilable conflict, were identical and interdependent, and that all questions between them could be settled by kindness, forbearance and patient investigation without resort to mistrust, suspicion, or antagonism. *He was the bearer of the only flag of truce that was ever carried upon the battle field of industrial strife.* Ignorance and prejudice have fired upon this flag, but it was never lowered, and now that the hand that carried it must relinquish its noble office, thousands of others will sustain it in its exalted position. I predict that it will never be lowered, and that the employer and the employee will both prosper under it as they have never prospered before, and with increasing respect, regard and solicitude for each other's welfare.

Many others have prayed for an industrial social millennium, expecting it to come from spiritual grace through lapse of time, but Dr. Taylor not only saw the possibilities of the future but he did more; he told in detail exactly how this long-hoped-for condition might be actually accomplished at once. The seed he has sown is springing up in thousands of places; the message he gave us is making hundreds, yes, even thousands of converts; the work he so ably started is based upon eternal truth and will partake of the lasting characteristics of its foundation.

### REMARKS BY M. L. COOKE

So much stress has been put upon the practical accomplishments of Frederick W. Taylor that the great reach and sweep of his *spirit* has, except for the few, been almost submerged. All this lifetime of patient, tireless investigation; all the acuteness of his highly scientific mind; all the aspirations of a sensitive nature were bent on the one end of making human life a better thing to live. To this object he made the freest possible sacrifice of his fortune, his time and his health.

The strength of the great movement which Mr. Taylor originated lay very largely in the devotion which we in the ranks felt for our leader. We rarely thought to call him a great man, it seemed like such a surface observation to any one who ever saw him at work. But we were always conscious of his incessant struggle, of the long weary years of battling to make men have faith in themselves.

He had a wonderful capacity for friendliness, a capacity that could stretch across seven seas, and last a lifetime and reach the lowest man in the ranks. He taught us our mutual dependence and then proceeded to carry nearly all the load. He tinged all our work with ideality. Hear his own words: "I can no longer afford to work for money"; "all

our inventions and changes are made to produce human happiness"; "in all your relations do to the other fellow what you would have him do to you." Just a year ago, Father Sertilanges, preaching in Paris, said: "The love of God is the Taylor system of our inner life (l'amour de Dieu est le systeme Taylor de notre vie interieure)." Mr. Taylor made us feel that there is nothing we cannot accomplish, and this without hurting our fellow men.

It was a part of the greatness of Mr. Taylor that he was not altogether concerned about the world's understanding of the greatness of his principles and motives. His loyal friends would do well to keep in mind his own words: "Patience, patience, and then more patience." His ideas forged ahead primarily because they were true and because they fitted in with the spirit of the time. But Taylor's "hanging on with his teeth," as he expressed it, and his willingness to stand alone when he was right, made them prevail.

Clean cut in his vision and keen in his judgments, fearless of criticism or misunderstanding, Frederick W. Taylor rang true in every act. He thought straight and spoke his mind with no uncertain sound and his speaking cleared the air of sophistries and evasions. No man who was ever honored by his friendship, sustained by his counsel, or upheld by his invincible spirit, can ever willingly set himself an easy task or be unwilling to tread the difficult way, so it be straight and clear.

FROM H. L. GANTT

Frederick Winslow Taylor's great contribution to the world's work was to substitute knowledge of human activities for opinion as a basis of action. His insistence that all industrial questions could be best answered by a scientific investigation was at first scoffed at by many of our industrial leaders, and it was nearly twenty years before he got much support. Now, however, at the end of thirty-five years, his persistence is bearing fruit so rapidly that the whole world is undergoing a revolution due to his ideas. His death cuts short the activities of a man who has had the welfare of his fellow men at heart, and who has devoted much of his life in trying to make clear the basis on which to establish industrial relations between employer and employee which shall be mutually satisfactory.

When he began his work all such relations were established by opinions. Today there are few industries in which fact has not supplanted many opinions. He had the feeling that waste was a crime, and that efficiency in work was a duty not only to ourselves and our employers, but to the community at large. His name will live as that of a man who could rise above individual cases and grasp general laws that would make for the happiness and prosperity of all.

If I were asked which piece of work more than any other illustrates his character as a man and an engineer, I would say the determination of the laws for cutting metals.

Finding himself balked at the outset of his career by a lack of knowledge on this subject, and realizing the great advantage that a knowledge of these laws would be to him and to the engineering profession in general, he determined to find out what they were. Suffice it to say that, although warned by his friends that he was attempting the impossible, and that for the first five years he scarcely made any real progress toward the desired end, he persisted in his work, to be rewarded after more than twenty years not only with the complete solution, but with the satisfaction of seeing the laws reduced to slide rules for their rapid application.

It was his persistent attempt to get uniformity in cutting tools that led, after nearly twenty years, to the discovery of the Taylor-White process of treating steel for cutting tools. This investigation involved at least fifty thousand experiments and cost probably over one hundred thousand dollars; the fact that he was able to carry to a successful conclusion such a gigantic undertaking in the face of the lukewarm support of his friends, and the determined opposition of all others, is a testimonial to his strength of character which needs no comments.

The solution of this problem will always be connected with his name as one of the greatest pieces of scientific investigation of the nineteenth century.

His discovery, in connection with Maunsel White, of the Taylor-White process, is a piece of scientific investigation almost as remarkable, and in its results quite as far reaching, for it is the basis of treating all the modern high-speed tool steels, which have so much reduced the cost of cutting metals. This discovery was the natural result of his habit of making a thorough investigation of every problem with which he was confronted, and fully justifies his practice of carrying investigations to their logical conclusions even though such conclusions seem contrary to all previous experience.

FROM THE ENGINEERING NEWS

The sudden death of Frederick W. Taylor removes from among us one of the acknowledged leaders of the engineering profession. Although his death occurs at a comparatively early age, Mr. Taylor had fully completed the great task of his life. His great achievement was the introduction to the engineering profession and to the industrial world of what has come to be known, for want of a better name, as scientific management.

It has been said that this was not originated by Mr. Taylor. Other men before him had followed, to a greater or less extent, the practice of setting tasks for workmen and giving them instructions as to the best methods of performing the task. This fact, however, detracts little from the great credit due Mr. Taylor as the originator of what was in effect a revolution in manufacturing industry. What others had attempted in an isolated and partial way, he did in a thorough manner and with a clear view of the underlying principles involved and the enormous scope and possibilities of the new system. By his personal force and ability, moreover, he brought the new system into extended use in a short time. Had it lacked such a strong and powerful advocate, its development would surely have been far slower and more uncertain.

It is unfortunately true that the system which he originated has been widely misunderstood and misapplied. Beside the school of able engineers who worked with Taylor and followed his methods and in many cases improved upon them, a host of imitators has sprung up everywhere who have nearly made the word efficiency a by-word of contempt. Misuse of the Taylor system to drive workmen beyond their strength has been one of the causes that has brought against it the antagonism of the labor unions. It is worth while to say at this time that nothing aroused the righteous wrath of Taylor more than the misuse of his system by employers as a tool to get more out of their hands. He always believed and always urged that an essential feature to the success of his system was that the profit representing the increased efficiency resulting from its application should be equitably divided between the workers and the employer.

That many faults and imperfections have developed in the operation of Taylor's system and similar systems which imitators have brought forth, will be freely acknowledged by impartial observers. It remains true nevertheless that the system of scientific management which he to a large extent created is probably the greatest labor-saving instrument that has been developed in modern times.

## THE SEE LIBRARY

Through the kindness of Mr. John Philp, Vice-President of the Glasgow Iron Works, New York, the Society has been the recipient of the collection of technical books forming the library of Horace See, who died December 14, 1909. Mr. See had given the library to Mr. Philp, but through the thoughtfulness of Mr. Philp the Society is now the owner of the books.

Mr. See was President of the Society in 1888, and was associated with the shipbuilding firm of William Cramp and Sons as designer and superintending engineer. It was under his leadership that the contracts for the first vessels of the " New Navy " of the United States were taken by his firm. He was also designing engineer for the transatlantic ships of the American Line.

The See Library is rich in the early works on naval architecture and the steam engine, especially the marine engine. It contains complete sets of several engineering periodicals and a large collection of pamphlets of a technical nature.

The collection will bear an appropriate special bookplate and will considerably strengthen the Society's contribution to the Library of the United Engineering Societies, where the collection will be catalogued and arranged.

## UNITED ENGINEERING SOCIETY

## REPORT OF TREASURER

To the Board of Trustees,
United Engineering Society.

I respectfully submit the following report of your Treasurer for the year ending December 31, 1914.

### FINANCES

The Balance Sheet submitted herewith shows the physical property of the United Engineering Society, over and above the value of the building and the equity in the land, to consist of building equipment of a value of $33,171.36, and library books $1,698.75.

There was added to Furniture and Fixtures Account during the year 1914 an amount representing an expenditure of $671.62, the principal items of which are: Typewriter for Library $100, two reflectors $50, cabinet $60, mail box $85, sign-boards $47.38, hall runner $37, and shades purchased during the year, $207. In accordance with a resotion of the Board of Trustees, the total amount of furniture and fixtures at December 31, 1914, viz., $6,467.08, has been written off.

The operations for the year 1914 resulted in a surplus of $13,383.60, against which amount there has been charged by direction of the Board of Trustees, the Furniture and Fixtures Account amounting to $6,467.08, also a transfer to Depreciation and Renewal Account of $20,000, leaving a charge to Surplus Account of $13,083.48, thus reducing the surplus of $43,437.96 of January 1, 1914 to $32,374.48.

The principal of the mortgage on the land held by Andrew Carnegie, Esq., amounting originally to $540,000, has been reduced by payments from the Land and Building Fund of the Founder Societies to $59,000. Payment of $29,000 was made during the year by the American Institute of Mining Engineers.

The present balances due from the Founder Societies are as follows: American Institute of Electrical Engineers, $54,000, and American Institute of Mining Engineers $5,000. The American Society of Mechanical Engineers has paid the full amount of its land indebtedness.

The gross operating expenses for the year 1914 were $39,581.64, as compared with $39,156.83 for the preceding year, showing an increase of $424.81 for the year.

In accordance with a resolution of the Board at a meeting held on February 26, 1914, an appropriation of $10,000 was made out of the surplus for the year 1913, and of this amount $9,900 was invested in the purchase of $10,000 Interborough Rapid Transit First Refunding 5% Bonds repayable 1966 at 99 as an addition to the Depreciation and Renewal Fund as provided for in the Founders Agreement, bringing the amount invested on account of this Fund to $39,863.75.

Pursuant to a resolution of the Board of Trustees at a meeting held November 19, 1914, all interest earned by the investments on account of the Depreciation and Renewal Fund is to be added to this Fund. For the year 1914 this interest amounted to $1,441.39, bringing the fund to $41,441.39. A further resolution at this meeting directed that a transfer from this Fund of $10,000 be made to " General Reserve Fund " to be available to take care of unforeseen fluctuations of income or outlay. The " Depreciation and Renewal Fund " to provide against gradual disappearance of this Society's assets now amounts to $31,441.39.

A resolution passed by the Board November 19, 1914, provided that a sum not exceeding $20,000 be transferred to Depreciation and Renewal Fund. On the advice of the Finance Committee acting under this resolution the entire sum of $20,000 was set aside.

The following summary shows the reserve accounts and the investments therefor:

| | |
|---|---|
| Depreciation and Renewal Fund | $30,000.00 |
| Add: Interest on invested funds, year 1914 | 1,441.39 |
| Transfer for the year 1914 | 20,000.00 |
| | $51,441.39 |
| General Reserve Fund | 10,000.00 |
| | $61,441.39 |

The investments made on account of these funds are as follows:

INVESTMENT

$10,000 Interborough Rapid Transit Bonds 1966.
5,000 N. Y. City 4½% Bonds 1917.
5,000 N. Y. City 4¼% Bonds 1930-1960.
5,000 N. Y. City 4¼% Bonds 1962.
5,000 Baltimore & Ohio 4% Bonds 1948.
5,000 Delaware & Hudson 4% Bonds 1943.
6,000 Southern Rwy. Co. 4% Bonds 1956.

PURCHASES OF JAN. 11, 1915.

10,000 Chicago & Northwestern 5% Bonds 1987.
8,000 Northern Pacific 4½% Bonds 2047.

$59,000

At the November meeting the Board of Trustees appointed the Astor Trust Company of New York City the custodian and attorney of the United Engineering Society

for the purpose of holding the securities and collecting the interest and dividends thereof, accordingly, the securities above listed have been deposited with the Astor Trust Company.

The assessments paid for the year 1914 by the Founder Societies, each apportioned one entire floor, were $3,375, representing as last year a total expenditure by each Society, including interest on its full principal of mortgage on land of $10,575, reduced in each case to the extent the Society may have paid off part or all of its mortgage share. The associate societies are assessed approximately $10,000 for equivalent privileges, which shows that the Founder Societies still meet a little more than their proportion of the carrying charges for equivalent office space occupancy in the building. In accordance with a resolution passed by the Board of Trustees November 19, 1914, each Founder Society will be assessed monthly at the rate of $12,000 per annum beginning January 1, 1915, and each society will be credited with 4 per cent upon the sum of its payments on account of its land mortgage, and a further credit for space released by any Founder Society.

BUILDING

*Equipment.* The Real Estate Equipment Account during the year 1914 has been increased to the extent of $5,814, expended mainly for labor and material for additions and alterations on the 6th floor of the United Engineering Building and architects' fees in connection therewith.

*Office Occupancy.* There was on January 1, 1914 no unoccupied floor space (devoted to office space) in the building. There are now seventeen associate societies occupying office space in the building.

*Meetings or Lectures.* The record of the number of times the rooms were used during 1914 for meetings or lectures (not for office occupancy) is:

MEETING ROOM.

| | Number of times occupied. | | |
|---|---|---|---|
| | 1913. | 1914. | Change. |
| Auditorium, 3d and 4th floors | 69 | 76 | 7 more. |
| No. 1 Assembly Room, 5th floor | 56 | 58 | 2 more. |
| No. 2 Assembly Room, 5th floor | 129 | 94 | 35 less. |
| No. 3 Assembly Room, 5th floor | 101 | 46 | 55 less. |
| No. 5 Lecture Room, 6th floor | 10 | 0 | 10 less. |
| No. 8 Lecture Room, 6th floor | 20 | 0 | 20 less. |
| Assembly Room 1201, 12th floor | 18 | 53 | 35 more. |
| Committee Room (off foyer), 1st floor | 10 | 18 | 8 more. |
| Total | 413 | 345 | 68 less. |

During the year 1914 the facilities of the building were used by 54 Societies holding a total of 251 meetings, with an attendance of 50,778 as compared with 56 Societies holding 309 meetings with an attendance of 63,348 during 1913.

LIBRARY

During the year 1914 there was added to the Library of the three Founder Societies and United Engineering Societies 3,616 volumes and pamphlets, of which 1,142 volumes and pamphlets were purchased at a cost of $3.153.20. The total number of books and pamphlets at the end of the year was 57,861.

The attendance during the year was 13,512 as compared with 11,091 during 1913, an increase of 2,421.

One hundred and ninety-eight Searches have been made during the year. Correspondence has come from all over the world, and the questions are of great variety. Several hundred photographic reproductions have been made and sent out. More than twelve hundred reference questions have been answered at the desk.

The Library receives more than 800 periodicals which are available through indexes for research purposes.

Respectfully submitted,

(*Signed*) JOS. STRUTHERS, *Treas.*

UNITED ENGINEERING SOCIETY

BALANCE SHEET, JANUARY 1, 1915.

ASSETS

| | | |
|---|---|---|
| Real Estate—Land | | $540,000.00 |
| Real Estate—Building | | 1,050,000.00 |
| Real Estate—Equipment | | 33,171.16 |
| Southern Railway Co. $6,000 4% Gold Bonds 1956 | | 4,755.00 |
| New York City $5,000 4½% Reg. Bonds 1917 | | 5,231.25 |
| Baltimore & Ohio $5,000 4% Cpn. Bonds 1948 | | 5,037.50 |
| New York City $5,000 4¼% Reg. Bonds 1930-1960 | | 5,062.50 |
| New York City $5,000 4¼% Cpn. Bonds 1962 | | 4,943.75 |
| Delaware & Hudson Co. $5,000 4% Cpn. Bonds 1943 | | 4,933.75 |
| Interboro R. T. Co. $10,000 5% Cpn. Bonds 1966 | | 9,900.00 |
| Library Books, U. E. S | | 1,688.75 |
| Library Adjustment Account | | 95.64 |
| Accounts Receivable | | 4,936.66 |
| Unexpired Insurance | | 3,333.10 |
| Cash: | | |
| Working Balance | $2,881.14 | |
| For Depreciation and Renewal Fund | 20,000.00 | |
| Ways and Means Committee | 1,165.08 | |
| | | 24,046.22 |
| Petty Cash | | 500.00 |
| | | $1,697,635.28 |

LIABILITIES

| | | |
|---|---|---|
| Balance of Land A. I. E. E | $54,000.00 | |
| Balance of Land A. I. M. E | 5,000.00 | |
| | | $59,000.00 |
| A. I. E. E. Equity in Building | | 350,000.00 |
| A. S. M. E. Equity in Building | | 350,000.00 |
| A. I. M. E. Equity in Building | | 350,000.00 |
| A. I. E. E. Equity in Real Estate Equipment | | 3,346.61 |
| A. S. M. E. Equity in Real Estate Equipment | | 3,346.62 |
| A. I. M. E. Equity in Real Estate Equipment | | 3,346.62 |
| A. I. E. E. Payments to date in liquidation of Mortgage on Land | | 126,000.00 |
| A. S. M. E. Payments to date on liquidation of Mortgage on Land | | 180,000.00 |
| A. I. M. E. Payments to date in liquidation of Mortgage on Land | | 175,000.00 |
| Depreciation and Renewal Fund | | 51,441.39 |
| General Reserve Fund | | 10,000.00 |
| Ways and Means Committee | | 1,165.08 |
| Library Adjustment Accounts | | 68.95 |
| Accounts payable | | 2,545.83 |
| Surplus Account | | 32,374.48 |
| | | $1,697,635.28 |

UNITED ENGINEERING SOCIETY

STATEMENT OF RECEIPTS AND DISBURSEMENTS, YEAR ENDING DECEMBER 31, 1914

CASH RECEIPTS

| | | |
|---|---|---|
| Balance on hand, January 1, 1914 | | $27,611.28 |
| Account of Interest on Mortgage | $3,365.73 | |
| Assessment—Founder Societies | 10,125.00 | |
| Assessment—Associate Societies, Offices, Meetings, etc. | 49,993.66 | |
| Library Account | 7,148.86 | |
| Interest on Bonds and Deposits | 2,238.27 | |
| A. I. M. E. in reduction of Mortgage | 29,000.00 | |
| | | 101,871.52 |
| | | $129,482.80 |

DISBURSEMENTS

| | |
|---|---|
| Account of Interest on Mortgage | $2,685.73 |
| Account of Real Estate Equipment | 5,814.00 |
| Operating Expenses—Cash Expenditure | 39,280.93 |
| Furniture and Fixtures | 653.62 |
| Library Account | 7,992.64 |
| Bonds Purchased — Depreciation and Renewal Fund | 9,900.00 |

| | | |
|---|---|---|
| Accrued Interest on Bonds Purchased | 98.61 | |
| Accounts Payable | 1,208.09 | |
| A. I. M. E.—Office Space Released | 3,912.00 | |
| Insurance | 3,423.66 | |
| Library Adjustment | 70.55 | |
| Payments in reduction of Mortgage | 29,000.00 | |
| Library administration expenses | 2,396.75 | |
| | | 105,436.58 |
| Balance on hand, January 1, 1915 | | 24,046.22 |
| | | $129,482.80 |

UNITED ENGINEERING SOCIETY

Operating Income and Expenses, Year Ended December 31, 1914

INCOME

| | | |
|---|---|---|
| Assessments: | | |
| Founder Societies | | $10,125.00 |
| Associate Societies | $32,004.81 | |
| Less: Refund for Office Space released | 3,912.00 | |
| | | 28,092.81 |
| Miscellaneous (Offices and Meetings) | | 10,916.16 |
| Telephone Returns | | 4,789.96 |
| Miscellaneous Charges to Societies, etc. | | 2,328.46 |
| United Engineering Society Library Returns | | 200.25 |
| Interest on Bank Balances | | 698.27 |
| Library Inventory Adjustment (Donations) | | 462.47 |
| | | $57,613.38 |
| Balance charged to Surplus Account | | 13,083.48 |
| | | $70,696.86 |

EXPENSES

| | |
|---|---|
| Operating Expenses, Gross | $39,581.64 |
| Insurance | 1,051.39 |
| Library Maintenance Expense | 1,200.00 |
| Library Administration Expense | 2,396.75 |
| Furniture and Fixtures written off | 6,467.08 |
| Depreciation and Renewal Fund | 20,000.00 |
| | $70,696.86 |

## ANNUAL DINNER AT BOSTON

The Sixth Annual Engineers' Dinner was held at the Boston City Club, February 15, 1915, under the auspices of the Boston Society of Civil Engineers, The American Society of Mechanical Engineers and The American Institute of Electrical Engineers; the arrangements this year being handled by the Boston Society of Civil Engineers. There were 271 at the dinner and it was a very enthusiastic gathering. The toastmaster was James W. Rollins, president of Holbrook, Cabot & Rollins, Engineers and Contractors. An account of the meeting follows:

The first speaker of the evening was Harrison P. Eddy of the firm Metcalf & Eddy, Consulting Engineers, who is President of the Boston Society of Civil Engineers.

Mr. Eddy heartily welcomed the engineers present and spoke of the great benefit to be derived from these annual dinners.

The next speaker was Charles W. Baker, Editor in Chief of the Engineering News who in speaking of the opportunities for public service by the engineer referred to the work some of the engineering societies are doing in the way of following up the bills which are being presented to the State Legislatures. The committees who do this work have to make a report, the matter is then discussed and if possible a change in the bill is agitated if necessary. As one looks out on the world today, he sees two great forces struggling with each other, conservatism and radicalism. Thirty years ago conservatism was in the lead, but since that time a most amazing change has taken place, and radicalism today is far in the lead but the great body of engineers should try to keep on the middle ground. The Child Labor Laws which are being agitated at the present day are causing quite an uproar all over the country. Intelligent men and women are on the platform in all the large centers speaking for more and more laws. The meaning of much of this is that every child should be prevented by law from performing any useful work before it reaches the age of 16 years. If this extreme ideal were carried into effect, we would produce a group of perfectly useless men and women. The enforced idleness which would take place would cause a great deal more harm than all the child labor now being performed. The boys and girls who were born and brought up on the New England hill sides and farms know what hard work means and in later years they know the joy of doing things.

Mr. Baker then touched upon the subject of government ownership and stated that probably within the next 25 years we should see the greater portion of the present day public utilities under government ownership. He said that he knew that some of the present day government methods are bad and that something must be done to correct them, and that it was up to engineers and the other men to give more time toward the correcting of the defects and take more interest in the affairs of government, city, state and national. Reforms should be put through so that these men can attain prominent positions and high rewards, and not lose their jobs every time there is a change of administration.

The next speaker was Chas. H. Eglee, manager dam and power dept. Aberthaw Construction Co. He said that the men today are losing their old ideas of standards and establishing new ones, which are better ones. He called attention to the various classes of engineers we have at the present day, the publicity engineer, mechanical engineer, hydraulic engineer, electrical engineer, mining engineer and steel engineer. Everything is trying to expand along new lines. The trade unions are trying to work as little as possible for as high a pay as possible in order that the working man may have an opportunity to improve himself; while on the other hand, the efficiency engineer with his stop watch is drifting in the direction of regarding a man as a machine. There we have the trade union on the one hand and the efficiency engineer on the other. The engineer, however, who is developing the finer qualities of manhood, giving each man an opportunity to expand as his individual qualifications make it possible, is the one who produces the productive man.

The next speaker was Capt. Robert W. Bartlett, the man who was the skipper of the ship Roosevelt when Peary discovered the North Pole and who later went with Steffanson up to the Arctic. He gave a number of personal experiences up in the North.

The Governor of the Commonwealth of Massachusetts, Hon. David I. Walsh, was the next speaker. He called attention to the great amount of good work the engineer could do by interesting himself in the affairs of the city and state, and spoke about the difficulty he had had in trying to induce engineering men to enter the public service. He hoped that the day would come when prominent engineers now in private practice would devote some of their time to the affairs of government.

## APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before May 10, 1915.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Alberger, Alvan H., Pres., Alberger Gas Eng. Co., Buffalo, N. Y.

Allen, Ethan E., Engr., Abaca Products Co., Manila, P. I.

Alverson, H. B., Supt. and Engr., The Cataract Pwr. & Conduit Co., Buffalo, N. Y.

Arff, John G. H., Supt. of Pwr., Christian Moerlein Brewing Co., Cincinnati, Ohio.

Baker, Robert E., Secy. and Treas., Arthur G. McKee & Co., Cleveland, Ohio

Barlow, Frederic C., with Phoenix Mfg. Co., Eau Claire, Wis.

Barr, Clarence D., Ch. Engr., American Cast Iron Pipe Co., Birmingham, Ala.

Beale, Horace A., Jr., Pres., Parkesburg Iron Co., Parkesburg, Pa.

Beebe, Lawrence L., Asst. Mech. Engr., Off. Pub. Rds., U. S. Dept. of Agri., Washington, D. C.

Bell, Edgar D., Genl. Supt., St. Louis Elec. Terminal Ry. Co., St. Louis, Mo.

Berggren, Axel E., Instr. in Steam and Gas Engrg., Univ. of Wisconsin, Madison, Wis.

Bever, John J., Mgr. Fdy. Dept., The Otis Steel Co., Cleveland, Ohio.

Boothman, Dale M., Ch. Draftsman, Shredded Wheat Co., Niagara Falls, N. Y.

Carey, Thomas H., Supt. Engrg. and Insp. Dept., Globe Indemnity Co., New York.

Carney, Joseph F., Mech. Supt., Greeley Square Hotel Co., New York.

Carson, Clarence, Cons. Engr., H. W. Johns-Manville Co., New York.

Chester, Thomas, Ch. Engr., American Blower Co., Detroit, Mich.

Cooney, James L., Supt., Cayuga Lake Plant, International Salt Co., Myers, N. Y.

Corbett, Charles F., Supt., City of Edmonton Filtration Plant, Alberta, Canada.

Dailey, Fred A., Pres. and Treas., Union Mch. Co., Contracting Engrs., St. Paul, Minn.

Decker, George A., Wks. Engr., The Warner & Swasey Co., Cleveland, Ohio.

Devine, Joseph P., 1372 Clinton St., Buffalo, N. Y.

DeWolf, Paul C., Asst. Treas., Brown & Sharpe Mfg. Co., Providence, R. I.

Dodge, Parker Van P., Patent Solicitor and Mem. of Firm, Dodge & Sons, Washington, D. C.

Durward, Eric S., Asst. Supt., California Oilfields, Ltd., San Francisco, Cal.

Eyre, Thomas T., Asst. Prof. of Mech. Engrg., Purdue Univ., Lafayette, Ind.

Fergusson, David, Mech. Engr., Pierce-Arrow Motor Car Co., Buffalo, N. Y.

Flanders, Warren B., Supt. of Pwr., Havana Elec. Rwy. Lt. & Pwr. Co., Havana, Cuba.

Freeman, Frederick S., Supt. Pwr. Operation, Boston Elevated Ry. Co., Boston, Mass.

Freeman, Herbert A., Designing Engr., G. M. Davis Co., Chicago, Ill.

Gardner, Archibald, Asst. to Pres., Ambursen Co., New York

Good, Paul E., Mech. Engr., Southwark Fdy. & Mch. Co., Philadelphia, Pa.

Goodling, H. P., with A. B. Farquhar Co. Ltd., York Pa.

Haggerty, Edward D., Supervising Engr., Employers Mutual Ins. Co., New York.

Hamilton, Robert, Mgr., Robt. Hamilton & Co., Vancouver, B. C., Canada.

Helmstaedter, William E., Mech. Engr., The Celluloid Co., Newark, N. J.

Herman, Samuel J., Vice Pres. and Genl. Mgr., Diamond Pwr. Specialty Co., Detroit, Mich.

Howard, Leslie E., Mech. Engr. and Metallurgist, Simonds Mfg. Co., Lockport, N. Y.

Howe, Charles S., Pres., Case School of Applied Science, Cleveland, Ohio.

James, William A., Ch. Engr., Lackawanna Steel Co., Buffalo, N. Y.

Inokuty, Ariya, Prof. of Mech. Engrg., College of Engrg., Imperial Univ. of Tokyo, Japan.

King, Walter A., Supt., Parker Bros. Gun Mfg. Co., Meriden, Conn.

Lacombe, Charles F., Cons. Engr., New York

Lambuth, Leonard L., Asst. Supt., The United States Portland Cement Co., Concrete, Colo.

Lane, George H., Secy. and Treas., C. J. Moberg, Inc., Mt. Vernon, N. Y.

Lehn, Henry C., with International Steam Pump Co., Buffalo, N. Y.

MacDonald, Karl, Ch. Mech. Engr., Clarksburg Water Wks. and Sewerage Board, Clarksburg, W. Va.

Mackie, Edwin M., Asst. Engr., Pneumelectric Mch. Co., Syracuse, N. Y.

Melendy, Jesse G., Supt., Buffalo Wks., General Chemical Co., Buffalo, N. Y.

Merrill, Edwin R., Plant Engr., The Niles Tool Wks. Co., Hamilton, Ohio

Murphy, Joseph E., Mgr. Mchy. Dept., Eccles & Smith Co., Inc., Los Angeles, Cal.

Nash, James E., Supt., Worcester Salt Co., Silver Springs, N. Y.

Neal, John R. H., with Robert Neal & Co., Buffalo, N. Y.

Newell, Frederick H., Cons. Engr., U. S. Reclamation Service, Washington, D. C.

Nielander, Theodore, Supt. Mech. Dept., Andrews Steel Co., Newport, Ky.

Noble, Warren, Cons. Engr., The Wagner Elec. Mfg. Co., St. Louis, Mo.

Oswald, James N., Ch. Engr., Duquesne Light Co., Pittsburgh, Pa.

Pelissier, Louis J., Genl. Foreman, Mch. Shop, Genl. Elec. Edison Lamp Wks., Harrison, N. J.

Philleo, George W., Master Mech., American Smelting & Refining Co., Leadville, Colo.

Reed, Richard D., with The H. B. Smith Co., Westfield, Mass.

Rennie, George J., with Wickwire Steel Co., Buffalo, N. Y.

Renshaw, Charles E., Pres., Newman Clock Co., New York.

Robbins, Newton A., Ch. Engr., and Master Mech., Orono Pulp & Paper Co., Bangor, Me.

Robertson, Lawrence B., Supt. Coke Dept., Maryland Steel Co., Sparrows Point, Md.

Robinson, T. Lorne, Draftsman, Canadian Copper Co., Copper Cliff, Ont., Canada

Schmeltzer, John E., Marine Eng. and Boiler Draftsman, United States Navy Dept., Navy Yard, New York.

Scott, Frank A., Secy. and Treas., The Warner & Swasey Co., Cleveland, Ohio

Short, Stanley, Asst. to Mgr., Mercer Wks., American Sheet & Tin Plate Co., Farrell, Pa.

Skewis, Edwin G., Erecting Engr., C. H. Wheeler Mfg. Co., Philadelphia, Pa.

Sowers, David W., Pres., Sowers Mfg. Co., Buffalo, N. Y.

Steinert, Otto K., Asst. Supt., Bar and Rod Mill, Dominion Iron & Steel Co., Ltd., Sydney, N. S., Canada.

Stephens, Harry H., Secy. and Engr., Dolier Centrifugal Pump & Mch. Co., Philadelphia, Pa.

Stoop, William J., Vice-Pres. and Genl. Mgr., Treadwell Engrg. Co., Easton, Pa.

Strachan, John E., Rep., The Midvale Steel Co., Philadelphia, Pa.

Straub, Harry L., Signal Engr., Elevator Supply & Repair Co., Chicago, Ill.

Thomas, Hugh K., Genl. Factory Supt. and Asst. Genl. Mgr., The Pierce-Arrow Motor Car Co., Buffalo, N. Y.

Turner, Guy S., Supt. of Central Sta., Memphis Cons. Gas & Elec. Co., Memphis, Tenn.

Travis, Stephen C., Asst. Supt., Worcester Salt Co., Silver Springs, N. Y.

Voy, Edward L., Mech. Engr., Aluminum Co. of America, Massena, N. Y.

Walsh, William F., Mech. Expert, Galena-Signal Oil Co., Franklin, Pa.

White, Walter J., Partner, Stanton & White, Dredging Contractors, Greenville, Miss.

Wray, Alfred B., with Morse Chairn Co., Ithaca, N. Y.

Wynne, Thomas A., Vice-Pres. and Treas., Indianapolis Light & Heat Co., Indianapolis, Ind.

Yeager, Andrew J., Jun. Partner, J. F. Witmer Co., Hydraulic and Sanitary Engrs., Buffalo, N. Y.

Zeh, Edmund W., Secy. and Treas., Zeh & Hahnemann Co., Newark, N. J.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Badowski, Alfred, Estimator, Pressed Steel Car Co., Pittsburgh, Pa.

Bohnstengel, Walter, Asst. to Engr. of Tests, Atchison, Topeka & Santa Fe Ry., Topeka, Kan.

Breyer, Emil F., Mech. Engr., St. Joseph Lead Co., Rivermines, Mo.

Brown, Mortimer C., Draftsman, Aetna Explosives Co., New York.

Bumbough, John B., Mgr., Enterprise Mch. Co., Asheville, N. C.

Chapman, Robert E. L., Ch. Engr., Bretton Woods Co., Bretton Woods, N. H.

Corneliussen, Olav S., Asst. Engr., Albert C. Wood, Cons. Engr., Philadelphia, Pa.

Cummins, Thomas C., with The New York Continental Jewell Filtration Co., New York.

Eddy, Harold F., Ch. Engr., Au Sable Elec. Co., Jackson, Mich.

Frank, Ernest J., Machinist, International Distillery, New Orleans, La.

Freeman, Herbert S., with Max Ams Mch. Co., Mt. Vernon, N. Y.

Gray, John R., Genl. Supt., La. State Rice Milling Co., New Orleans, La.

Guba, Philip M., with Jones & Laughlin Steel Co., Pittsburgh, Pa.

Hanson, John J., Mech. Designer on Drafting on Fuel Oil Plants for Panama Canal, Balboa Heights, C. Z.

Hitze, Edward C., Genl. Supt., Edward Valve & Mfg. Co., Chicago, Ill.

Homewood, John, Ch. Draftsman, The Bauroth Mch. & Tool Co., Toledo, Ohio.

Kaelin, Charles G., Supt., Pierce Cycle Co., Buffalo, N. Y.

Lefren, Karl A. A., Engr. with John A. Stevens, Cons. Engr., Lowell, Mass.

Lockard, James P., Asst. to Steam Engr., Lackawanna Steel Co., Buffalo, N. Y.

McNally, John H., Smoke Inspector, Bureau of Boiler Inspection, Philadelphia, Pa.

MacArthur, Clarence P., Master Mechanic, Bowen Mfg. Co., Auburn, N. Y.

Martin, Edward C., Prof. of Mch. Design, Ohio Mechanics Inst., Cincinnati, Ohio.

Pelot, Joseph H., Captain, Ordnance Dept., U. S. Army, Benicia, Cal.

Rathbun, Sherrill S., Instr. Exper. Engrg., Univ. of Penn., Philadelphia, Pa.

Rohmer, Gabriel E., Engr., National Lead Co., New York.

Rousseau, Edwin H., Designer, Dibert, Bancroft & Ross Co., Ltd., New Orleans, La.

Rueck, George, Mgr., Messer & Co., Philadelphia, Pa.

Schaff, Frederic A., Asst. to Vice-Pres., Locomotive Superheater Co., New York

Schafer, Robert H., Mech. Engr., Glenlyon Dye Wks., Saylesville, R. I.

Servey, Dan F., Mech. Engr., Hunt Engrg. Co., Kansas City, Mo.

Slater, Surrey W., Acting Asst. Supt., Holder Distrib. Dept., The Brooklyn Union Gas Co., Brooklyn, N. Y.

Slidell, Kemper, Engr., Robert L. Latimer & Co., Philadelphia, Pa.

Standifer, Ernest H., Asst. Dist. Engr., The Southern Cotton Oil Co., Montgomery, Ala.

Taylor, Robert J., formerly with Best Mfg. Co., Kansas City, Mo.

Terry, M. Victor, Draftsman and Asst. to Ch. Engr., Champion Ignition Co., Flint, Mich.

Yewdall, Francis M., Mech. Engr., Wm. Steele & Sons Co., Philadelphia, Pa.

FOR CONSIDERATION AS JUNIOR

Abrams, Frank W., Engr., Standard Oil Co., Jersey City, N. J.

Azbe, Victor J., Combustion Engr., Anheuser-Busch Brew. Assoc., St. Louis, Mo.

Bardo, Benjamin F., Asst. Engr. Pwr. Dept., New York, New Haven & Hartford R. R. Co., New Haven, Conn.

Bayer, Lloyd F., Cadet Engr., Distrib. Dept., New York and Queens Elec. Lt. & Pwr. Co., Long Island City, N. Y.

Benjamin, Harrie L., Lab. Asst. in Materials Testing, Yale University, New Haven, Conn.

Bixby, Winfred H., Asst. Engr., C., B. & Q. R. R. Co., Guernsey, Wyo.

Blackburn, Charles H., formerly with The Green Fuel Economizer Co., Beacon, N. Y.

Blackford, Ralph E., Tool Designer, The Miami Cycle Mfg. Co., Middletown, Ohio

Bunge, Ralph W., Htg. and Ventlg. Engr., American Foundry & Furnace Co., Bloomington, Ill.

Butler, Thomas M., Genl. Foreman, Bauroth Mch. & Tool Co., Toledo, Ohio

Castro-Gamboa, Francisco, Student, Ohio Northern Univ., Ada, Ohio.

Corbett, Melvin C., Asst. in Mch. Design, Yale University, New Haven, Conn.

Couch, Alger D., Asst. to Steam Engr., Edgar Thompson Wks., Carnegie Steel Co., Braddock, Pa.

Cunningham, Francis, Mech. Engr., with John A. Stevens, Cons. Engr., Lowell, Mass.

Foster, Charles C., Liability Inspector, Fidelity & Casualty Co., New York.

Ganschow, Lloyd W., Student, Ohio State Univ., Columbus, Ohio.

Gremmel, Henry F., Draftsman and Estimator, Blaisdell-Canady Co., New York.

Harder, Lewis F., Asst. Supt., High Rock Knitting Co., Philmont, N. Y.

Hart, Howard P., with Platt Bros. & Co., Waterbury, Conn.

Henshall, Percival P., Instr. in Mch. Shop Practice, Pennsylvania State College, State College, Pa.

Hicks, Rufus W., Jr., Mech. Engr., Workmen's Compensation Service Bureau, New York.

Jones, Robert J., Turbine Engrg. Dept., General Elec. Co., Lynn, Mass.

Jones, Rufus B., Engrg. Draftsman, Packard Motor Car Co., Detroit, Mich.

Kessler, Herbert H., Engrg., Asst. Supt., Pwr. and Maintenance, The Atlas Portland Cement Co., Hannibal, Mo.

Kupfer, Otto, Jr., with D. C. & Wm. B. Jackson, Boston, Mass.

Lyon, Percy S., Exper. Engr., Harrison Safety Boiler Wks., Philadelphia, Pa.

Lucht, Frederick W., Jr., with Michigan Railway Commission, Ann Arbor, Mich.

Martin, Hubert H., Ch. Inspector, Northwestern Mut. Fire Association, Seattle, Wash.

Miller, Philip F., with Pacific Flush Tank Co., New York.

Moy, Frank, First Asst. Inspector, Bureau of Gas, Dept. of Public Wks., Philadelphia, Pa.

Mueller, Charles, Draftsman, E. I. du Pont de Nemours Pwdr. Co., Wilmington, Del.

Oakley, Alfred W., Tech. Dept., Jacob Ruppert Brewery, New York

Parthesius, Henry J., Special Apprentice, New York Central R. R., West Albany, N. Y.

Reed, Charles M., Engrg. Observer, U. S. Naval Engrg. Exper. Sta., Annapolis, Md.

Repko, John S. Jr., Mech. Draftsman, Sulzberger Meat Packers Co., Queens, L. I., N. Y.

Robertson, Elroy C., Cons. Engr., H. H. Franklin Mfg. Co., Syracuse, N. Y.

Ross, Cleland C., Mech. Engr., Coldwell Lawn Mower Co., Newburgh, N. Y.

Royer, Daniel L., Inspector, Ocean Accident & Guarantee Corp. Ltd., Milwaukee, Wis.

Russell, James G., Instr. in Mech. Engrg., Post Grad. Dept., U. S. Naval Academy, Annapolis, Md.

Scheid, Hugo, Ch. Draftsman, Combustion Engrg. Corp., New York.

Summers, Daniel, Student, Yale University, New Haven, Conn.

Swift, Harley L., with General Railway Signal Co., Rochester, N. Y.

Tag, Walter, Steam Tester, Transit Development Co., Brooklyn, N. Y.

Thomas, John M., with Harold Almert, Cons. Engr. of Chicago, Washington, D. C.

Tilson, Howard, Mgr. Ill. Div., Workmens Compensation Service Bureau, Chicago, Ill.

Turley, Charles L., Supt. and Engr., Portsmouth Eng. Co., Portsmouth, Ohio.

Wadsworth, John F., Assoc., Richard Irvin & Co., Architects and Engrs., Pittsburgh, Pa.

Van Syckel, Frederick T., with International Steam Pump Co., St. Paul, Minn.

Vogt, Clarence W., Asst. Supt., Henry Vogt Mch. Co., Louisville, Ky.

Welch, Albert E., Asst. Engr., Spreckels Sugar Refining Co., Philadelphia, Pa.

Werner, Philip J., Inspr. of Engrg. Materials, Panama Canal, Washington, D. C.

Wilkinson, Robert E., Jr., Engr. in Pwr. Plant, Jackson Light & Traction Co., Jackson, Miss.

Wilson, James A., Special Work, Cleveland, Chicago, Cincinnati & St. Louis Rwy., Indianapolis, Ind.

Wyman, Dwight M., Supt. of Equipment Installation, Aberthaw Constr. Co., New Haven, Conn.

## APPLICATIONS FOR CHANGE OF GRADING

### PROMOTION FROM ASSOCIATE

Bump, Archie E., Mgr. Constr. and Mech. Depts., Swift & Co., Boston, Mass.

Kinkead, James A., Res. Sales Mgr., Parkesburg Iron Co., New York.

Smith, George M., Vice-Pres. and Treas., A. E. Anderson & Co., Buffalo, N. Y.

### PROMOTION FROM JUNIOR

Alger, Harley C., Mgr., Water Weigher Dept., The Kennicott Co., Chicago Heights, Ill.

Corp, Charles I., Asst. Prof. of Hyd. Engrg., Univ. of Wis., Madison, Wis.

Doughty, William F., Mech. Engr., Flushing, L. I., N. Y.

Helmes, Maximilian J., Cons. Engr., Westminster, London, S. W., England.

Hendee, Edward T., Secy. and Mgr. of Mchy. Dept., Joseph T. Ryerson & Son, Chicago, Ill.

Jones, Reid, Associated with Bartlett & Ranney, Inc., Cons. Engrs., San Antonio, Tex.

Meyer, Erwin C., with Steeneck & Stegge, Detroit, Mich.

Ray, Frederick, Cons. Engr., 50 Church Street, New York

Sague, Samuel R., with The Strong, Carlisle & Hammond Co., Cleveland, Ohio.

Woolley, Harold O., with Power Specialty Co., Dansville, N. Y.

Zachert, Arthur R., Ch. of Production Dept., Babcock & Wilcox Co., Bayonne, N. J.

## SUMMARY

| | |
|---|---|
| New applications | 176 |
| Applications for change of grading: | |
| Promotion from Associate | 3 |
| Promotion from Junior | 11 |
| | 190 |

# THE CLINKERING OF COAL

BY LIONEL S. MARKS, CAMBRIDGE, MASS.

Member of the Society

*The Friday morning Session of the Annual Meeting, December 4, 1914, was devoted to a number of papers upon miscellaneous subjects. Five of these appeared in abstract in the March Issue of The Journal, pages 159 to 179. The remaining paper of this group, The Clinkering of Coal by Lionel S. Marks, is here presented in abstract form together with abstracts of the discussion which followed.*

THERE is a growing feeling that the matter of clinkering ought to be taken care of when making contracts for coal and that specifications ought to include the melting temperature of the ash as indicating the clinkering characteristics of the coal.

The useful items in modern specifications for coal are the heat of combustion of the coal and its water and ash content. The latter permit calculation of the cost of handling inert matter when firing the coal and when disposing of the ashpit refuse. The volatile content of coal has an indirect interest in indicating its general nature but does not give any definite information about burning qualities. The important things about which specifications give no information are (*a*) as to the burning qualities of the coal (free burning or dead, caking or non-caking, etc.) and (*b*) the clinkering characteristics of the ash.

Before the subject of clinkering can be put upon a satisfactory basis, two kinds of measurement are necessary; (*a*) the determination of the extent to which the clinkering of a given coal is objectionable in actual use, and (*b*) the determination by a laboratory test of some characteristic of the ash which indicates the objectionableness of the clinkering. Some clinkers give very little trouble and are not particularly objectionable even when present in large amount. This is especially true of such clinkers as are non-adherent, easily broken up and easily removed. On the other hand, a small quantity of clinker which forms a pasty mass with the surrounding coal, or which runs on to the grate and freezes there as a strongly adherent but thin sheet, gives a very great deal of trouble and diminishes both the capacity and efficiency of a boiler considerably.

It is probable that the only reliable basis at present for determining the "objectionableness" of the clinker, is the judgment of fireroom observers. The writer has attempted to get a quantitative measurement by sifting the ashpit refuse into a number of selected sizes. In tests made with a Murphy stoker equipped with the usual clinker-breaker, the coals which gave most trouble were found to have the lowest percentage of smallest size clinker (less than 1 in.), and the highest percentage of the largest size clinker (greater than 2 in.). The differences between the percentages of the different sizes for good and poor coals is but small, so that the method cannot be relied on, but these observations have been used to confirm the judgment of the fire-room observers.

The only kind of laboratory test on coal ash which would seem to be of any real value is one in which the ash is subjected to such temperature as will cause it to melt either wholly or in part. A number of attempts have been made to determine the melting temperature of an ash from its chemical analysis, but none of these attempts has been satisfactory, nor does it seem probable that this method will ever be available in view of the great complexity of the chemical constitution of coal ash.

That valuable indications may be obtained from a knowledge of the iron and sulphur content of the coal or of its ash, is suggested by some recent tests of Palmenbnrg[1] which, as pointed out by Bergwyn,[2] appear to show the following results:

*a* An ash containing less than 10 per cent of iron oxide ($Fe_2O_3$) does not fuse at a temperature below 2550 deg. fahr.; an ash containing more than 20 per cent does not fuse at a temperature above 2550 deg. fahr.; for an ash containing between 10 and 20 per cent the fusing temperature varies widely.

*b* A coal containing less than 1 per cent of sulphur does not fuse at a temperature below 2550 deg. fahr.; a coal containing more than 2 per cent does not fuse at a temperature above 2550 deg. fahr.; for a coal containtaining between 1 and 2 per cent the fusing temperature varies widely.

*c* A coal containing less than 3 per cent of iron oxide plus sulphur does not fuse below 2550 deg. fahr.; and a coal containing more than 3 per cent does not fuse above 2550 deg. fahr.

The determination of melting temperatures of coal ash is attended with many difficulties, the most important of which is in the definition of the melting temperature. When a coal ash is heated slowly, that one of its constituents which is the most fusible will be the first to melt. Its effect upon the rest of the ash will depend upon three factors: (*a*) the amount of that constituent; (*b*) its viscosity when melted; and (*c*) its chemical reaction on the remaining constituents. If there is much of this constituent the ash will become fluid to an extent which depends upon its viscosity. If the molten part is small in amount but very fluid, it may separate from the rest. With certain constituents, a eutectic may be formed whose melting temperature has but little relation to the melting temperatures of the constituents.

The best method of determining the extent to which melting has gone on at any given temperature, is probably that which has been used so successfully by the Geophysical Laboratory at Washington. In this method a small mass of the ash is kept at the desired temperature for a time sufficient to insure that the melting corresponding to that temperature is complete. The melt is then quenched and a thin

Abstract of paper and discussion presented at the Annual Meeting, December, 1914. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

[1] Journal of Industrial and Engineering Chemistry, April, 1914.

[2] Journal of Industrial and Engineering Chemistry, August, 1914.

section of it is examined under the microscope. This method, however, may not be the most valuable for the determination of the clinkering characteristics of an ash.

There is another factor of great importance in connection with the behavior of molten coal ash, namely, its viscosity, which a satisfactory laboratory test for clinkering should indicate as well as melting temperature. The only method which has been used to any extent for this purpose, is really an imperfect method of determining the temperature at which the material has a standard viscosity. This is accomplished by heating the material in the form of a Seger cone of standard dimensions, at a standard rate, until it has bent to some standardized final form. The cone has usually been set up vertically. The rate of rise of temperature is usually taken as 2 deg. cent. (or 4 deg. fahr.) per minute, and the melting temperature is taken as that at which the tip of the cone touches the base. This method, it will be observed, does not really give a standard viscosity unless the time from the beginning of bending is the same in all cases. It should be noted also that the temperature of the cone increases as the bending goes on.

In tests by the writer with a standard rate of heating of 2 deg. cent. per minute, the time taken for the cone to bend to its final position from the beginning of bending, has varied

Fig. 1 Appearance, after Fusion, of a Cone Containing a Very Fluid Constituent

from 10 to 80 minutes; the final viscosities in these two cases are obviously very different. It should be noted that even if this method gave standard viscosities, it would not necessarily give information of any value on clinkering. If it were true that all clinkers became troublesome when they reached a certain lower limit of viscosity, and if that particular viscosity were chosen as the standard, one might expect a close relation between laboratory and fireroom results. It has not, however, been shown that there is a lower limit of viscosity of the ash which cannot be exceeded without trouble from clinker, and moreover, in ashes whose most fusible constituents are very fluid the Seger cone method fails as indicated above.

Notwithstanding these inherent defects, the Seger cone method appears to merit further investigation, but an important modification in its use seems to be advisable. In the standard method the cones are placed vertically. This gives satisfactory results with the original Seger cones with many fire clays, but is often unsatisfactory with more complex mixtures. If the more fusible constituents are very fluid they run down to the base of the cone and may leave the apex apparently unchanged in a vertical or slightly inclined position (Fig. 1) until it disappears; that is, the cone never assumes the standard final shape. Furthermore, even cones which behave in the normal way may be difficult to observe since their direction of bending is not readily predictable or controllable without preliminary inclining or nicking. Mr. J. P. Sparrow of the New York Edison Company has suggested placing the cones horizontally with the apex projecting over the side of the support. This method has been adopted by the writer as being more sensitive than the usual method and as giving indications which can be duplicated more accurately and are therefore more reliable. The temperatures noted in this method of testing are at the beginning of bending and when the apex of the cone points vertically downward.

The Seger cone method with the cone placed either vertically or horizontally, is used by a number of observers, but with an enormous diversity of the results obtained in different laboratories. This diversity results from differences in methods of testing, from differences in the definition of melting temperature, and also from the difficulties surrounding accurate pyrometric work. The writer has endeavored to ascertain the influence of the various factors which may affect the apparent melting temperature. The more important factors are (*a*) nature of the surrounding atmosphere; (*b*) size of the cone; (*c*) position of the cone; (*d*) nature of the binder; (*e*) rate of heating; (*f*) location of the cone in the furnace; and (*g*) method of support of the cone.

TABLE 1 INFLUENCE OF POSITION OF CONE ON MELTING TEMPERATURE

| Date | Melting Temperature Deg. Cent. | | Difference Deg. Cent. |
|---|---|---|---|
| | Vertical Cone | Horizontal Cone | |
| Feb. 3 | 1430 | 1395 | 35 |
| 4 | 1410 | 1400 | 10 |
| 5 | 1410 | 1400 | 10 |
| 6 | 1390 | 1380 | 10 |
| 10 | 1380 | 1370 | 10 |
| 13 | 1440 | 1395 | 45 |
| Mar. 3 | 1440 | 1420 | 20 |
| 5 | 1365 | 1370 | 5 |
| 11 | 1400 | 1380 | 20 |
| 13 | 1445 | 1395 | 50 |
| 24 | 1470 | 1450 | 20 |
| Seger No. 12 (full size) | 1350 | 1300 | 50 |
| Seger No. 16 (small size) | 1450 | 1420 | 30 |

*a Nature of Surrounding Atmosphere.* Many of the writer's earlier tests were made with a Hoskins carbon resistance furnace in which the atmosphere is necessarily reducing and in which CO is always present. Preliminary tests on Seger cones gave results which agreed very closely with the readings of a Fery optical pyrometer. The melting temperature of the standard Seger cones was found to be unaffected by the nature of the surrounding atmosphere. With ash cones, however, it was found that the fusing temperatures, as observed in the Hoskins furnace, were in all cases much higher than those obtained in a Meker furnace in which an oxidizing atmosphere was maintained. The temperature in the Meker furnace was read by a Le Chatelier pyrometer which showed close agreement both with the Fery pyrometer and with the indications of Seger cones. The cones were all vertical, and the temperature differences ranged from 120 deg. to 255 deg. cent. (260 deg. to 459 deg. fahr.). It should be noted also that even the order of fusibility was changed in some cases when the at-

mosphere is changed, and that the lower the fusing temperature in an oxidizing atmosphere the greater is the increase in fusing temperature when changing to a reducing atmosphere. It is of prime importance that the cone should be surrounded by an oxidizing atmosphere.

*b* *Size of Cone.* The size of cone has an influence which is different for different materials. With Seger cones the difference is negligible. For example, a No. 16 Seger cone (17 mm base, 70 mm high) placed horizontally, has a melting temperature (initial and final bending) of 1355 to 1410 deg. cent.; when molded into the standard size of Seger cones of higher fusing temperature (8 mm base, 30 mm high), the result is 1355 to 1420 deg. cent. The size of cone adopted in the writer's tests was 11 mm base and 52 mm high. The ash of March 24 tested horizontally in a cone of this size gave melting temperature 1425-1450 deg. cent.; in a 13 mm base, 57 mm high cone, the temperature was 1400-1430 deg. cent. As is to be expected, the larger cones show a lower melting temperature but the difference is not great.

*c* *Position of Cone.* The melting temperature (complete bending) of a horizontal cone is always less than for a vertical cone, as shown by Table 1. The difference varies considerably and is less with the more fluid melts. The cones of March 5 or February 10 showed a particularly fluid melt.

*d* *Nature of Binder.* The ash is usually mixed with a 10 per cent solution of dextrin before molding into cones. It was found, however, that water alone was satisfactory if the cones are not dried much before putting in the furnace. The effect of adding dextrin is generally negligible, but sometimes it increases the apparent fusing temperature (complete bending) by as much as 10 deg. cent.

*e* *The Rate of Heating Cones* has a marked effect on the apparent fusing temperature. Any increase in the rate results in increased lag of the pyrometer (Le Chatelier type with porcelain tube), and causes an apparent decrease in the melting temperature. Tests on the ash for February 4 and February 6 showed melting temperatures (complete bending) which were 40 deg. and 35 deg. cent. respectively lower, with 6 deg. cent. increase per minute, than with 2 deg. cent. increase per minute.

*f* *The Location of the Cone* in the furnace is important; it should be as close to the pyrometric element as possible. The temperature at the front of a No. 29 Meker furnace was found to be about 20 deg. cent. lower than that in the middle of the muffle. An additional door plate reduced this difference.

*g* *The Cone must be Supported* on material which is unaffected by the highest temperature reached and which does not react chemically on the ash cones. Plates of fused quartz have proved very satisfactory in the writer's tests. They have to be supported in such a way as to permit circulation of the gases below them so that they shall have the same temperature as the rest of the muffle.

Another point of importance is the complete incineration of the ash before it is made into a cone. An appreciable amount of carbon remaining unburned tends to increase the apparent fusing temperature.

The arrangement of apparatus finally used in the writer's tests is shown in Fig. 2. Holes were made in the back of the furnace for the insertion of the pyrometer, and in front for observation and for the insertion of a quartz tube through which a stream of air was introduced into the muffle to ensure an oxidizing atmosphere. The furnace was heated rapidly to within about 200 deg. cent. of the expected fusing temperature and the rate was then reduced to 2 deg. cent. per min., and was kept there. The observation hole was plugged up except when in use. Observations were made through very dark blue glass at 2½ min. intervals. The horizontal cones were supported only so far as was necessary for balance.

In order to find out whether fusing temperatures as determined by the method outlined above, have any relation to the amount of clinker trouble experienced in burning the coal, a series of tests was carried out on a boiler equipped with a Murphy Stoker at the L Street plant of the Edison Electric Illuminating Company of Boston. Fourteen tests were made, each of 24 hours duration, with 10 different coals; 5 of the tests were made with one coal, and 1 test with each

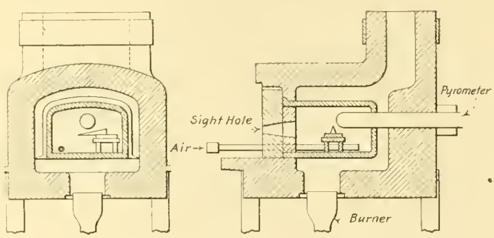



Fig. 2 Arrangement of Apparatus used in Tests

of the 9 remaining coals. Table 2 gives the results of tests of the ash and a statement of the extent of the clinkering for each of these tests.

It will be seen that there is a general relation between the two but that it is not definite enough to be of much practical use. The coals giving the three lowest fusing temperatures (February 10, March 5, April 8) are also those giving the maximum clinker trouble. Those ashes with a final fusing temperature of 1400 deg. cent. (2552 deg. fahr.) or higher, gave little trouble, but the ash of February 6, which melted at 1380 deg. cent. (2516 deg. fahr.) gave little trouble, while those of February 13 and March 13 which melted at 1395 deg. cent. (2543 deg. fahr.) gave much trouble. The most troublesome clinkers (February 10, March 5 and April 8) had final melting temperatures of 1370 to 1375 deg. cent. (2498 to 2507 deg. fahr.) which is practically the same as the temperature for the good coal of February 6. It would appear then, that the final melting temperature cannot be taken as a criterion in the range from 1380 to 1400 deg. cent. (2516 to 2552 deg. fahr.) and the inference is that the uncertain region extends over a still wider temperature range. It is probably true that final fusing temperatures below 1350 deg. cent. (2462 deg. fahr.) show a coal which would give clinker trouble under the conditions of the L Street Station, and that temperatures above 1420

deg. cent. (2588 deg. fahr.) indicate a coal comparatively free from such trouble, but further investigation would be necessary to establish that fact. The important thing, however, from the point of view of coal specifications, is that the tests of the ash of February 3, 4, 5 and 6, when the regular station coal was used which gave a minimum of clinker trouble, yield results which fall in the doubtful region and would therefore be rejected in coal specifications based on fusing temperatures alone.

Additional indications of the liability to clinker trouble may be obtained from the range of temperature during bending and from the appearance of the bent cone. The cones of the ash which gave most trouble had a very fluid constituent which ran down to the tip of the cone and also upon the supporting plate and gave the appearance shown in Fig. 3; those giving least trouble were as in Fig. 4. It would appear that the most fusible constituents will separate from the rest of the cone when it is very fluid, leaving a skeleton

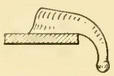


Fig. 3 Fused Cone with Very Fluid Constituent

Fig. 4 Normal Fused Cone

which does not bend until its own fusing temperature is reached; that is, with the kind of ash which gives most trouble, the Seger cone method fails as a result of the separation of the more fusible from the less fusible constituents.

It is possible to accept the appearance of the bent cone as a partial indication of the clinkering behavior, and it may be possible to predict the behavior of an ash from that indication combined with the fusing temperature. The range of temperature during bending may also possibly be used. The range varies from 15 deg. to 55 deg. cent. in the tests given in Table 1; in other tests by the writer it has amounted to as much as 140 deg. cent. There seems to be a very close relation between this range and the viscosity of the melted cone. The ash cones of February 10 and March 5 show the smallest range and they also show greater fluidity (Fig. 3) than any of the other cones. It should be noted, however, that there is a liability to error in observing the initial and final bending temperatures, which is not less than 10 deg. cent. so that an observed range of temperature of 30 deg. may actually be anywhere from 10 deg. to 50 deg. cent.; it is necessary to make several determinations in order to get the range with reasonable certainty. The appearance of the melted cone is consequently more valuable than the range of fusing temperature.

The investigations of the writer seem to show that under the conditions of combustion at the L Street plant of the Edison Electric Illuminating Company of Boston a coal with a fusing temperature (final bending) below about 1400 deg. cent. (2550 deg. fahr.) will probably give trouble if the ash has a fluid constituent; whereas, it will not give trouble above about 1380 deg. cent. (2516 deg. fahr.) if the ash is viscous. This conclusion would require further investigation with many other coals before it could be accepted even for this particular plant; naturally it cannot be applied to plants with different operating conditions.

TABLE 2 MELTING TEMPERATURE OF ASH AND FIRE ROOM RECORD OF CLINKERING

| Date | Melting Temperatures Deg. Cent. (Fahr.) | | Amount and Character of Clinker |
|---|---|---|---|
| | Initial and Final Bending | Range | |
| Feb. 3 | 1350–1395 (2462–2543) | 45 (81) | Light |
| 4 | 1360–1400 (2480–2552) | 40 (72) | Light |
| 5 | 1360–1400 (2480–2552) | 40 (72) | Light |
| 6 | 1340–1380 (2444–2516) | 40 (72) | Light |
| 10 | 1360–1375 (2480–2507) | 15 (27) | Hard, excessive; 50 per cent of grate |
| 13 | 1350–1395 (2462–2543) | 45 (81) | Excessive to moderate; large clinker |
| Mar. 3 | 1370–1420 (2498–2588) | 50 (90) | Not much, but very hard and isolated |
| 5 | 1350–1370 (2462–2498) | 20 (36) | Excessive; 75 per cent of grate |
| 11 | 1355–1380 (2471–2516) | 25 (45) | Heavy |
| 13 | 1340–1395 (2444–2543) | 55 (99) | Heavy |
| 17 | 1430–1480 (2606–2696) | 50 (90) | Light |
| 24 | 1420–1450 (2588–2642) | 30 (54) | Very little |
| 26 | >1500 ( >2732) | | Light, hard |
| Apr. 8 | 1335–1370 (2435–2498) | 35 (63) | Excessive; very hard, 18 to 20 in. in V and thick |

## DISCUSSION

F. C. Hubley,[1] referring to the author's statement that a satisfactory laboratory test for clinkering should indicate viscosity as well as melting temperature, said it would probably be well to go further and state that such a test should indicate viscosity at any temperature throughout the softening range, and furthermore it should be of such a positive and definite nature that results from the same sample but from different laboratories, would agree closely. In searching for a more definite form of test than the various cone methods present, the writer finally adopted a test in which the collapse of an ash cylinder, under a slight vertical pressure, due to softening, is plotted against increasing temperature to form a curve, the shape and extent of which apparently present a complete picture of the nature and position of the softening range of the ash under test. The ash cylinder is formed without the use of a binder, from the completely incinerated pulverized ash, in a press exerting 30,000 lb. pressure per sq. in. on the cylinder.

Mr. Hubley gave a description of a fusiometer, which after experimenting in the construction of various designs of this instrument, has been adopted in the form shown in Fig. 5, as being best suited, mechanically speaking, to carry out the proposed fusion tests. A test pellet $W$ is held centrally in the furnace $A$ by carbon rods $C$ and $D$ which are ordinary arc lamp carbons ½ in. in diameter. Rod $D$ is held by a clamp $E$ to the bottom of the furnace body and rod $C$ and weights $L$ and $N$ are free to move vertically, carrying in this particular instrument, weights designed to exert a unit pressure of 1.5 lb. per sq. in. on the pellet. This rod is held on the center line of the instrument by four guide wheels and a silk cord over a pivoted pulley connects this rod and weights with a counter weight $P$. A pointer $V$ is fixed to this pivoted pulley and indicates on a scale on plate $U$; the pulley is 1 in. in diameter and the pointer 6 in. long, so that any vertical movement of the carbon

[1] P. O. Box 202, Cynwyd, Pa.

rod $C$ due to softening of the test pellet $W$, is magnified twelve times on the scale, the total collapse of a pellet $\frac{5}{8}$ in. in height being indicated by a movement of the pointer over $7\frac{1}{2}$ units on the scale. The several parts of the instrument are supported on two $1\frac{1}{2}$ inch diameter rods, fixed in a heavy cast iron base. This construction is considered necessary to obtain proper rigidity of the fixed points.

In experiments carried out by the writer, a gas-heated

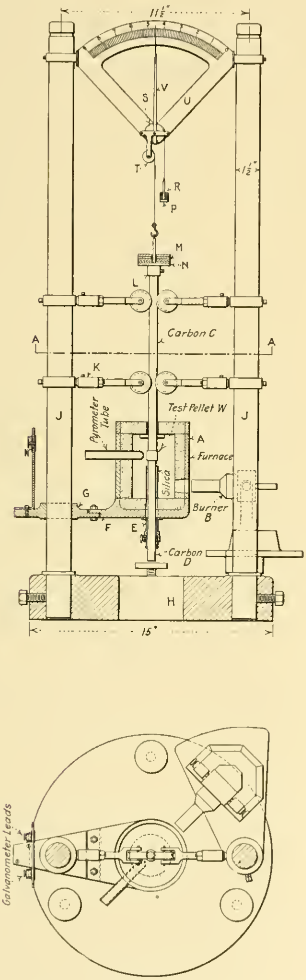



Fig. 5 Elevation and Plan of Fusiometer

furnace was used. Regarding the time to make tests, eight tests, including making of pellets, were performed in three and one-half hours, averaging 26 min. per test. This time compares favorably with the time required to make a proximate analysis or a B.t.u. determination on fuel. During this performance the carbon rods were reduced from $\frac{1}{2}$ in. in diameter to $\frac{3}{8}$ in. in diameter at the pellet. Frequent replacement of these rods may be made since their cost is negligible.

Mr. Hubley explained the method of making the test and stated that, with the ash pellet and carbons in the position shown, and the pointer $V$ adjusted midway between zero and 1.00 on the scale, the furnace is gradually heated at the rate of from 50 to 100 deg. fahr. per minute, simultaneous temperature and scale readings being made at one-half minute intervals. As the heat is increased negative movement of the pointer will indicate carbon expansion up to a temperature where first softening of the ash pellet is indicated by a positive movement of the pointer. The experiment is continued till final collapse of the pellet is indicated on the scale. These results if plotted, the temperatures as abscissae and the pointer movement as ordinates, produce a curve, an ordinate of which at any point is a measure of the relative rate of softening of the ash pellet at that temperature.

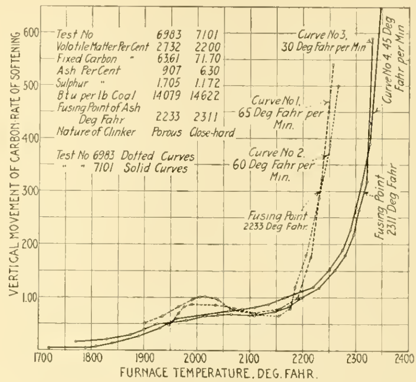



Fig. 6 Ash Fusion Tests on Middle Pennsylvania Coals with Fusiometer

He stated that the length of the softening range, and its position on the temperature scale in relation to the working temperature range of a boiler fire, as well as the increasing rate of softening, whether gradual throughout the range (indicating high viscosity), or very slight for most of the range, followed by a sudden collapse, are the factors in the fusiometer results which must be considered in predicting the probable clinkering action of a coal in a boiler fire. A long range ash with a slow but steady increase in softness, *apparently indicated by the gently sloping curve*, is productive of the close gummy clinker of high viscosity. This type, provided the softening range coincides approximately with the working temperature range of the boiler, produces the greatest losses from clinker formation in a boiler fire. This refers more particularly to stokers in which the fires are cleaned at regular intervals by a dropping of the back grates.

The other type of ash fusion is a short range spongy porous formation of low viscosity, which if it does not occur too low on the temperature scale, can be handled with ease in the boiler fires. From a comparison of boiler house results with a large number of tests made, the fusiometer curve for this type of fusion appears to be distinguished by a most decided downward dip in the curve just prior to final softening.

Mr. Hubley pointed out the fact that the term "fusing point" is misleading and indeterminate, while "fusing

range" of a substance can be determined with exactitude. For purposes of relative comparison, however, an arbitrary point in the fusing range may be selected and called the "fusing point" of the ash. For this point in the case of the fusiometer results, he suggests the temperature at which the pellet has collapsed due to softening, to one-half of its original height.

Mr. Hubley discussed several curves developed from a number of ash tests, using this instrument, together with boiler house reports in regard to the nature and extent of clinker formed under actual operating conditions. He showed tests of two samples that indicated a wide variation in the viscosity of melt between ashes fusing at approximately the same temperature, and pointed out the futility of using only the relative ash "fusing points" to grade

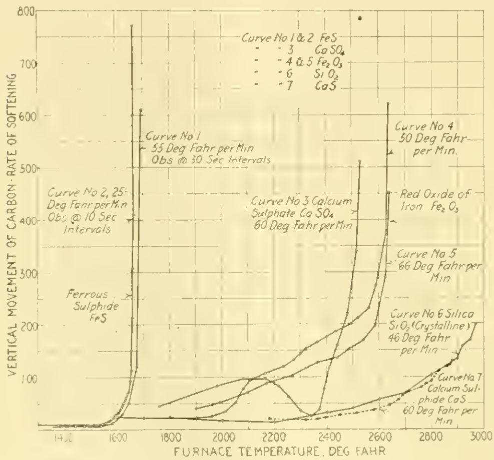



Fig. 7 Fusing Range of Ash Constituents using Fusiometer

coals as to their probable freedom from clinkering trouble, without considering also viscosity and length of softening range (see Fig. 6). One of these coals formed a porous clinker easily broken up and the other a close gummy clinker difficult to remove from the firebox. A number of similar graphical records of tests were shown that clearly indicated the characteristics of the coals tested.

Mr. Hubley showed in Fig. 7 curves for calcium sulphate and the red oxide of iron that are interesting, since they represent, in shape, the two extremes of coal ash fusion. Of the total number of ash samples tested by this method, a large percentage of those melting between 2100 and 2500 deg. fahr. show indications in varying degree of the dip in the calcium sulphate curve. Also, a coal ash producing a fusion curve similar to that of the sulphate, shows a low viscosity of meld and will produce a porous brittle clinker easily broken up and removed from the fire box; while an ash producing a curve similar to the ferric oxide fusion, indicates high viscosity and the production of a tough gummy clinker difficult to break up and remove from the fire box.

He showed that the first type of fusion, while causing no excessive delay at cleaning periods, is productive of dirty fire and a high percentage loss of carbon in the ash pits. The second type not only causes delay at cleaning periods, but increases the wear on the grate bars and brick work, in addition to cutting down the capacity and efficiency of the boiler as a whole. One of the effects of this type of fusion is to arch over the back grates on a stoker, preventing the admission of air necessary to economically burn down a fire preparatory to cleaning.

The expansion of a pellet of calcium sulphate, between 2100 and 2350 deg. fahr. or prior to the melting point, would indicate the evolution and release of a gas between these temperatures. He is still seeking an explanation of this occurrence, since this curve was reproduced a number of times both in shape and position on the temperature scale; first in the presence of reducing agents and later with the carbon rods covered with platinum ferrules and an excess of air in the furnace gases.

He referred to Fig. 8, which shows fusiometer tests on a three-car shipment of coal from a certain mine and illustrates a number of important points bearing on the clinker problem.

*First.* Curves 1 and 2 show the accuracy which may be obtained on duplicate samples from the same ash. He

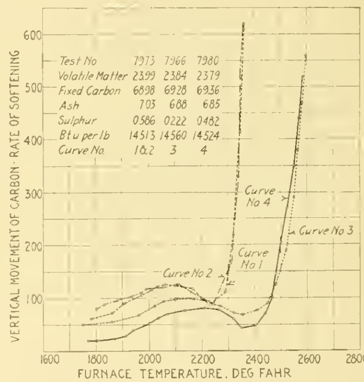



Fig. 8 Softening Range of Bituminous Coal Ashes from Fuel used in Taylor Stokers

believes that if complete incineration and thorough pulverizing and mixing of the ash sample occurs previous to testing, the accuracy shown in Curves 1 and 2 and in some of the previous illustrations may be obtained in each case. It follows therefore that two different laboratories, both using this method, could be expected to show a correspondingly close agreement in results obtained, a circumstance which appears to be conspicuously lacking where modifications of the Seger cone method are used. This is an important point if the clinkering characteristic of fuel is to be regulated by a specification based on the method of determination of softening temperature.

*Second.* Fig. 8 also illustrates that three cars of coal from the same mine, although showing the most remarkable uniformity as to proximate analysis, sulphur content and heating value, will vary considerably as to fusibility of ash. It has been found at times that the ash in the roof or large partings in a vein will vary considerably in fusibility with the true ash of the coal, but in this case it would appear,

from the uniformly low ash obtained in each car, that in this vein or mine the true ash itself varied in fusibility.

*Third.* As actually tested, these three cars were used in Taylor Stokers with Rust boilers operating at 180 per cent of rated capacity. At this rate, fuel bed temperatures as high as 2800 deg. fahr. have been observed with the Fery radiation pyrometer, with an average of over 2700 deg. The boiler room reported as follows: "This coal proved to be unsatisfactory inasmuch as it clinkered to a troublesome extent. Coal contained in Test No. 7973 appeared to make a much harder clinker than either of the other cars." It would appear therefore that, knowing the approximate fuel bed temperatures under which this coal was to be consumed, the degree of probable clinker trouble in using this fuel under these load conditions could have been predicted from the curves in Fig. 8. The fact that a porous easily removed clinker was not formed (as would be ordinarily indicated by the dip in the curves previous to melting) is probably due to the high fuel bed temperature at which this fuel was consumed, a temperature far above the final melting temperature of any one of these ash samples. In other words, had fuels represented by Curves 3 and 4 been consumed at fuel bed temperatures of 2500 deg. fahr. or under, a porous easily removed clinker would probably have been formed. The same can be said of fuel represented by Curves 1 and 2 for fuel bed temperatures of 2300 deg. fahr. or under. For Babcock & Wilcox boilers with Roney Stokers, 2500 deg. corresponds to a load of approximately 150 per cent of rating and 2300 deg. to 110 per cent of rating.

It has often been noted, in a boiler fire room, that in burning a fuel which produced a not too troublesome clinker, if for one reason or another the fire is not thoroughly cleaned at one fire-cleaning period, the clinker not removed at this period will give excessive trouble in removal at the next succeeding period. One sample shown could give trouble of this nature, not because of the reduced temperature at which this ash re-fuses but due to a change in viscosity of the re-fused mass.

Basing an opinion on this form of test, the writer suggests the following specification: The pellet shall not have collapsed due to softening, to more than one-half of the original height at a temperature *T*, and in addition, shall not show a collapse of more than one-eighth of the original height due to softening at a temperature 300 deg. fahr. under temperature *T*. The first part of this specification will limit the final fusion, while the second part is intended to control viscosity and avoid the sloping curve shown in Tests No. 7124, Fig. 7 and 7201, Fig. 6.

Referring to Fig. 9, the position of the line A-A or the fixing of temperature *T* must vary for plant conditions. It is obvious that the buying field for steam coal will be restricted or broadened according as the temperature T is raised or lowered, so that the fixing of this temperature must be governed by the value which a plant management places on loss of boiler capacity, and risk of steam failure against the saving made in purchasing the cheaper fuel.

O. W. Palmenberg[1] offered a method of testing which he follows and which he has found to give satisfactory results when comparing laboratory tests with results as obtained in practice. He uses a gas muffle furnace heated with a double blast Meker burner and by this means can attain temperatures ranging as high as 3000 deg. fahr. The rate of heating is under good control and the temperatures required can be obtained conveniently. The muffle is uniformly heated, the flame passing around it, and has a door with a small opening for observation. The temperature readings are made with an optical pyrometer which is standardized in the usual way with an Amyl Acetate flame every time before making a fusing test, care being taken to have conditions as nearly alike as possible.

The coal ash which has been burned free of carbon and heated to insure oxidation of the iron, is made into a round thin cone 1½ to 2 in. high weighing about one gram or less. This form is placed upon a thin piece of Battersea fireclay in a vertical position and set in the middle of the muffle. After heating the furnace, the blast is applied rapidly at

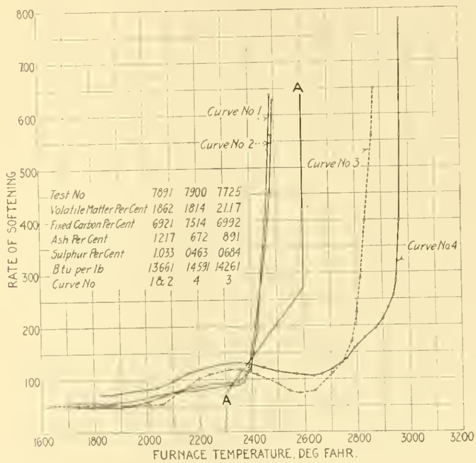



Fig. 9 Softening Range of Bituminous Coal Ashes from Fuel used in Taylor Stokers

first until the temperature is nearly that at which the form begins to bend. Then the heat is regulated carefully and readings made every five minutes or oftener depending upon the rate of heating; care must be taken to have the heating carried on slowly. As soon as the cone shows signs of bending the temperature is noted and the operation continued until the cone has completely bent over and touched the plate, the temperature at which the point touches the plate being called the fusing temperature.

He has made a large number of fusing tests by this method, as regular routine laboratory work in connection with coal analyses, and considers the information on fusing temperature tests on coal ash of the greatest importance. While it may be true that the fusing test does not at times agree with results as obtained in practice, this may be said of any other kind of laboratory test, but when a practical test is at variance with a laboratory test the cause may usually be found and accounted for. The laboratory test gives an important clue as to the value of a coal for certain furnace conditions which cannot otherwise be readily and conveniently ascertained.

In reply is Prof. Marks' statement "relative to the separa-

[1] 50 East 41st St., New York.

tion of the more fusible constituents and thereby leaving a skeleton which fuses at a higher temperature," Mr. Palmenberg said that this difficulty does not seem to present itself when the cones are made long and thin, at least not to interfere with the tests. If the ash is thoroughly ground and mixed he believes that a complete fusion of the whole mass should take place. Furthermore, by making the ash into a long and thin form, it tends to help retain its shape during the whole time of heating and gives tests that can be duplicated to a fair degree of accuracy. The weight and height of the form does not make much difference with most coals but it is no doubt a good practice to have a standard size so that the results may be compared.

He said that whether a small amount of carbon left in the ash has any appreciable effect upon the fusing temperature will no doubt depend upon the conditions of the test and the nature of the coal ash; he had found that as much as 10 per cent carbon had no effect. If much iron is present the carbon may influence the test, but as a rule all the carbon will have burned off before fusion takes place. It is of course advisable to have no carbon present in the cone so that no reduction of the $Fe_2O_3$ can take place thereby raising the fusing temperature.

In regard to Mr. Hubley's statement about the relation of the fusing test to the iron oxide and sulfur, he said they seem to bear out in a general way further investigations of his that high iron and high sulfur coals give a low fusing ash, but low iron and low sulfur coals do not necessarily produce high fusing ash. The tests referred to were made on coals from Pennsylvania and as they all bear a certain relation to each other there would naturally be a corresponding relation in the fusing tests; when coal from other sources are tested the findings are very different, so that the iron or sulfur content does not always give an indication of the fusing temperature of the ash. He had recently tested the ash of a coal from Texas in which the iron oxide ($Fe_2O_3$) was 10.76 per cent and had a fusing temperature of only 2138 deg. fahr.

As a further illustration to show the variable influence of iron oxide and sulfur, he presented records of tests on two lots of coal coming from Cambria county, Pa., mined from the "B" vein, the mines being about 50 miles apart. The coals in the first group represented samples taken from the face of the vein at various parts of the mine, the coals in the second group represent samples taken from deliveries. This latter coal is noted for its uniformity in quality, being prepared in a careful manner at the mine on a picking belt before being dumped into the railroad cars. In comparing the results of these two coals it is found that the first group has an ash fusing more than 100 deg. higher than that of the second group, although the $Fe_2O_3$ is somewhat higher and the sulfur about the same. There seems to be no strict relation of the iron and sulfur to the fusing test in either case. The results on the first group coal showed plainly the variations obtained on samples taken from the face of the vein, whereas the average samples obtained in the second group coal shipments showed few variations. The second group coal samples being obtained from a larger bulk gave a more uniform mixture of the ash constituents. These fusion tests covered a period of many months and therefore the various determinations were made under different conditions.

Mr. Palmenberg referred to a few analyses that he had made on the ash samples before and after fusing, which indicated an increase of $Fe_2O_3$ in the fused cone and this he explained by the fact that these coal ashes lose some of their constituents during heating and thereby increase the ratio of the iron to the other parts. He said that the volatile constituents may be $CO_2$ from the rbonates and $H_2O$ from water of combination in the silic ates. The ash samples were subjected to heating in a flat silica dish with a blast flame, prior to being made into a cone for fusing, the object being to assure complete oxidation of the iron.

To show the accuracy with which fusing tests may be made, he presented records of a few duplicate determinations and Seger cone tests which he had chosen from a number of tests made in routine work. He commended Prof. Marks for the splendid and convincing manner in which he has pointed out the variable conditions met with in the work of obtaining the fusing temperature of coal ash and hoped that they may lead in the near future to the selection of a standard method for this important and valuable kind of work.

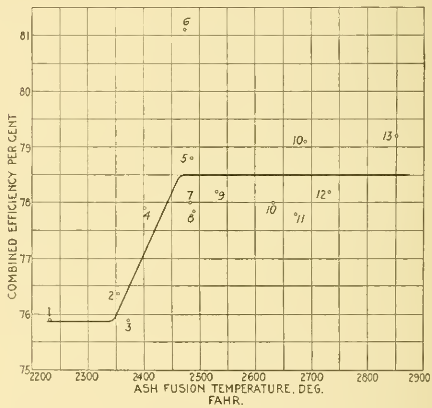



Fig. 10 Efficiency vs. Ash Fusion Temperature

O. P. Hood[1] stated that laboratory methods should work towards the end that a laboratory treatment of a small sample will indicate the results that can be expected from that coal in actual practice. He said there will always be lack of agreement with commercial results until furnaces and the treatment of fires are as carefully standardized as are the laboratory methods. Calorimetric determinations have been of great value, but the potential ability of the coal thus disclosed is not made available in the furnace because of numerous unfavorable factors. He finds these factors each require careful study and may some day find their place in coal specifications. The matter of clinkering is one of the most important. If, he said, the seriousness of the clinker difficulty holds some definite relation to the fusing temperature, then a laboratory determination of fusibility becomes desirable. It can not as yet be said that such a relation is established in any large sense although the assumption seems reasonable. Some coals with a low

[1] Chief Mechanical Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.

fusing temperature of the ash give no trouble with clinkering. Some coals with a high fusing temperature give trouble under certain methods of handling. He stated that there is practically no knowledge available as to the relation between laboratory results and clinker formation under furnace conditions, and that the U. S. Bureau of Mines has consistently opposed the use of fusing-temperature tests in the purchase of coal under specifications by the Government until a thorough investigation of the subject should disclose the relation between these laboratory tests and actual furnace conditions and clinker troubles.

Realizing that the results obtained for fusing temperature under different conditions of rate of heating, oxidation, and reduction would vary greatly, and that an extended investigation with a view to standardizing the laboratory test was necessary before a comparison with actual clinkering tests in commercial furnaces could be undertaken, an investigation has been conducted by A. F. Fieldner and A. E. Hall in the Pittsburgh laboratory of the Bureau of Mines, and Professor Hood stated their conclusions from the work done before July 1, 1914, as follows:

A complex mixture of oxides and silicates like coal ash has no definite melting point. On heating a sample of coal ash it first cinters, then gradually softens into a more or less viscous slag. Hence in assigning a "fusing" or softening temperature we can only take some point or temperature range where the material reaches a certain stage of softening or degree of fluidity. The temperature at which the visible softening takes place is affected by a number of factors:

1. Oxidizing or reducing atmosphere;
2. Fineness of ash;
3. Shape of test piece;
4. Rate of heating.

The effect of these factors on the softening of ash molded into small pyramids similar to Seger cones, has been studied, and the results prepared for publication.

It is evident from the results obtained thus far that variations in the conditions under which laboratory tests are made may cause variations in the so-called fusing temperature of several hundred deg. cent., and that the fusing temperature of the ignited ash of a coal is not the only factor in the clinkering properties of the coal.

Prof. Hood pointed out that, contrary to Prof. Marks' results on the effect of oxidizing and reducing atmospheres, Fieldner and Hall do not conclude that the fusing temperature in reducing atmospheres is always higher than in oxidizing atmospheres. Their investigation, which covered some fifty different coals, showed in some cases higher results in reducing atmospheres and in other cases lower results. The difference varied with the composition of the ash and the extent of reduction that took place in the test furnace. Furthermore, they do not conclude that the test should necessarily be made in an oxidizing atmosphere. Conditions in the fuel bed are variable. There are regions where ash forms in the presence of reducing agents. Incandescent carbon, CO, hydrogen and hydrocarbon gases are good reducing agents. The possibility of clinker formation under reducing conditions must therefore be considered. Keeping this in mind, the Bureau is making further investigations of the slagging of ash under the various possible fuel-bed conditions. The first step in this work is now being prepared for publication.

He further pointed out that, after a consistent laboratory method is devised whereby different laboratories can obtain comparable results there yet remains the correlation of these results with actual experience in the furnace to determine what value fusibility tests may have in coal specifications.

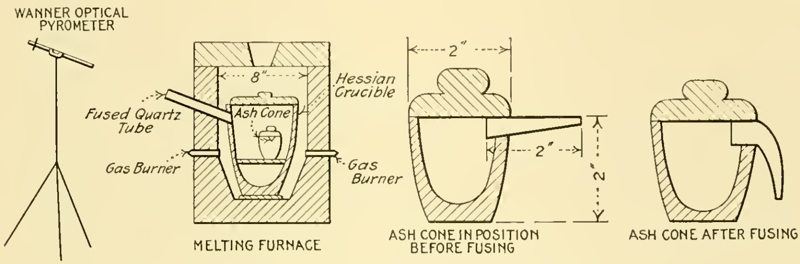



Fig. 11 Apparatus used in Determining the Fusibility of Coal Ash

E. B. Ricketts referred to a series of tests made to determine the value of coal clinkering and ash fusion data to the power plant manager in its effect on the efficiency and capacity of the boiler plant. The tests were made in the spring of 1914 on a 650 h.p. Babcock & Wilcox boiler fired by a Taylor stoker. The boiler output was maintained at about 825 h.p. throughout the test except for one hour when the boiler was forced to between 1250 and 1700 h.p. The boiler was cleaned before each test and the conditions were maintained as nearly constant as possible throughout the series of tests. Most of these tests were of 120 hr. duration. In all thirteen coals having ash fusion temperatures varying from 2225 to 2850 deg. fahr. were tested, the results of which are shown in Fig. 10. Mr. Ricketts pointed out that this curve is practically two discontinuous lines with a critical zone between 2375 and 2450 deg. fahr. Lowering the fusion point from 2375 to 2225 deg., or raising it from 2450 to 2850 deg. has no effect on the efficiency, thus leaving a zone of uncertainty of about 75 deg. where the clinkering effect is doubtful. This critical zone covers the errors in testing and differences in fire conditions.

Mr. Ricketts stated that the above curve probably covers all ordinary operating conditions for Taylor stokers, but it is easily possible that the critical zone for another type

of stoker may be at a different part of the curve. In applying the results of the above tests, he has evolved the following method of determining coal values: taking any coal, the cost and analysis of which is known, as a standard, the relative value of any other coal of known composition can be determined by the following formula:

$A$ = B.t.u. per lb. standard coal $\times$ efficiency from curve

$B$ = B.t.u. per lb. coal $X$ $\times$ efficiency from curve

$C$ = Cost per ton of coal of transportation to bunkers and disposal of refuse for each per cent of ash in coal

$$D = \frac{(\text{Per cent ash coal } X - \text{per cent ash standard coal}) \times C}{\text{Cost per ton of standard coal in bunkers}}$$

Value of coal $X$ in per cent of standard coal =

$$\left(\frac{B}{A} \pm C\right) \times 100$$

The above method of coal valuation differs, he stated, from those heretofore proposed in that the burning qualities of the coal are given proper weight and the detrimental effect of high ash is properly discounted.

Also the method used by Mr. Ricketts for determining ash fusion temperatures differs somewhat from that described by Prof. Marks. About two pounds of coal are coked in a crucible in a gas furnace for about an hour after which the lump of coke is broken up and a stream of compressed air is fed in near the bottom of the crucible for from two to three hours until the coke is all reduced to ash. When burning the coke down, care should be taken to keep the temperature below 1500 deg. fahr. so as to prevent premature fusion. The ash is then tested a small amount at a time with oxygen to make sure that all the carbon is consumed. It is of vital importance that no carbon be left in the ash as a small trace may cause results several hundred degrees too high. The carbon free ash is moistened with a little water and moulded in a paper cone $2\frac{1}{2}$ in. long and $\frac{1}{2}$ in. base. The cones are dried for five or six hours and then fused in a muffle furnace without removing the paper in which it was moulded. The cone is so placed that it overhangs the point of support about $1\frac{1}{2}$ in. The point of fusion is taken when the cone reaches a 45 deg. position and is read on a Wanner optical pyrometer. (See Fig. 11.)

The question of correct melting point is in Mr. Ricketts' opinion one of minor importance so long as the results obtained are consistent. With the above described method they are able to check the same sample of coal within a few degrees and his observation of the action in the fire room of several hundred cargoes of coal from some twenty-five different sources on which ash fusion tests have been made, has consistently confirmed the results given in the test curve.

P. F. Walker called attention to conditions under which coal may give trouble, depending very largely upon the method of handling. He referred to a situation where he had had trouble in the use of a coal with a very large amount of ash, on both hand fired grates and with stokers. He had found, however, that the firemen might be taught to handle their fires so that the difficulties are vastly different in the one case from those in the other.

Roger DeWolf questioned a point in the early part of Prof. Marks' paper in which a non-adhering clinker was referred to. He stated that if an ash does melt and form a non-adhering clinker, it gives very little trouble, as there is a very great difference between various coals in this regard. He asked if any work had been done that would indicate a method of determining the adherent qualities of the clinker.

The Author said that Mr. Ricketts, in speaking of the work of the New York Edison Company, showed a curve of fusing temperatures, and their relations to clinkering troubles. My own investigations would, apparently, give just about the same results but there is this difference: I have exchanged samples of ash with the New York Edison Laboratory, and my fusing temperatures come out consistently about 200 deg. higher than those obtained at the New York Edison Company. I have calibrated my pyrometer by the melting point of nickel and by the use of the Seger cone, and I feel sure of my pyrometric work. They feel sure of their pyrometric work. Though we both come to the same conclusions, they are based on the indications of pyrometers which are strongly discordant.

F. C. Hubley, in speaking of this matter of discordant results between the New York Edison Laboratory and Professor Marks, said there is a rather interesting coincidence in this connection. We have Taylor stokers, forced draft, and very troublesome peak loads, a mill-load in other words, and we have specified 2700 deg. as the so-called fusing point of the ash. If you take the difference between Professor Marks' figures, I believe he stated 260 deg., and the average acceptable figure, specified by the New York Edison Company of 2450, you will obtain a figure of 2700 deg. fahr. I have personally measured the fuel bed temperature in Taylor stokers with a radiation pyrometer, with 200 per cent radiation, and for temperature of 2700 fahr. It would appear, therefore, as though the New York Edison Company have either misjudged the temperature of their fuel bed, or have been in error in the figures obtained in the laboratory.

# SPAULDING-DRUM POWER DEVELOPMENT

BY JOHN A. BRITTON, SAN FRANCISCO, CAL.

Member of the Society

THE location of the Spaulding Dam is on the South Yuba River near Emigrant Gap. The drainage area is 120 sq. miles, and a dam 300 ft. high will ultimately be required to conserve the run-off. The water after being released from the dam will pass through six power houses; one of these, the Drum Power Station, is completed and has been in operation for nearly a year, and four have their foundations laid. A total head of over 4000 ft. will be utilized. After passing through the sixth power house, the water is to enter the irrigation system by means of which it will be possible to irrigate over 60,000 acres of land.

FIG. 1 GENERAL VIEW OF THE SOUTH YUBA RIVER GORGE, BELOW SITE OF THE SPAULDING DAM

The foundation of the Spaulding Dam was placed in November and December 1912, and the dam was "poured" between May and December 1913, so that the 150,000 cu. yd. in the dam was placed in less than nine months. The reservoir was filled on February 1, 1914, to an elevation of 225 ft. and Drum Plant was put in operation on November 26, 1913. The entire work was carried through ahead of schedule and estimates of costs were realized.

Features of the Spaulding Dam which will interest engineers and construction men are:

- *a* The method of construction, especially with reference to obtaining speed of construction
- *b* The variable radius arch design
- *c* The expansion joints
- *d* The drainage system
- *e* The water control or discharge system

Abstract of paper presented at the San Francisco local meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on September 10, 1914.

*a* As results were required from the development by the end of 1913, it was necessary to select such a method of construction as would ensure completion by that time, and reject anything that would not meet that condition.

It was at first proposed to build the dam from concrete made of crushed granite and a sand and gravel found near the dam. This local gravel would not stand the test of crushing strength, namely over 1000 lb. per sq. in. at ninety days, and therefore had to be rejected. Finally, a gravel deposit was selected on the Bear River near Colfax. This material was very well graded, clean, made excellent concrete and was located in such position that the desired speed of supply could be obtained. The material was loaded by steam shovel into 30 cu. yd. gondola cars and hauled to Colfax over the track of the Nevada County Narrow Gauge Railroad. The cars were dumped into large bunkers at an elevation of about 375 ft. above the bottom of the dam.

From the storage bunkers the gravel was conveyed by belt conveyors to service bins located over four one-yard Smith mixers. From thence, the concrete was carried by chutes to towers located over the dam and from these towers it was distributed by chutes to the part of the dam desired. For the lower part of the dam, the concrete was dropped through a series of baffles to the elevation desired, from whence it was carried by chutes to its destination. In falling through this set of baffles the mixing was materially aided. At the end where the concrete towers were located, after the dam had reached the grade of the chute from the mixing plant, the concrete was elevated by belt conveyors and distributed from other towers and chutes. The concrete was allowed,

as far as possible, to flow onto the dam by its own weight—like a lava flow—and only five men were required to distribute 1000 to 2000 yd. per day. The grade of the chutes was 5 in. per ft. and of the belt conveyors 18 deg. and 20 deg. The speed of the belt was about 420 ft. per minute and a 28 in. belt was used.

This is, I believe, the first concrete that has been successfully transported by belt conveyors. Successful transportation depends on a wide belt, well-troughed, and on keeping the belt clean. To clean the belt a rotating brush, a stream of water and a compressed air jet were used. A thousand yards of concrete per day were easily handled over a single belt, and tests showed as high as 200 yd. per hr.

The gravel mixture was tested hourly at the gravel pit and samples were again taken on the belt conveyors at the mixing plant. Any deficiency was made up by crushed rock, or sand as required. Three samples of the concrete were taken off the dam daily and these were tested at 7, 28, and 90 days, six months and a year. The location where sample was taken was marked on each, so that records of the strength of the dam at all points and of the increase of strength with age are available.

*b* The dam site immediately suggested an arched dam, as the walls of the canyon are solid granite and converge downstream. The scientific design of any structure demands that factors of safety throughout shall be consistent in order that a structure of uniform strength may result; and, since in building an arched dam across a river canyon, we are really building sections of a pipe spanning the canyon, in order to build a dam of uniform factor of safety from top to bottom, the thickness of the dam must vary with the width of canyon and with the head of water. These considerations lead to a design having a variable radius, increasing as the canyon becomes wider. This results in a structure having uniform elasticity, as far as possible, all parts of the concrete being strained practically to the same amount. The design is calculated for a strain of 24 tons per sq. ft., assuming all the strain to be taken up by arch action. Ultimately, the dam will be carried up to an elevation of about 300 ft.

The arch type of dam requires no more labor in building forms than does the single radius arch, although it involves more work for the instrument men in locating the lines. The increasing radius, as the canyon width increases, gives a natural batter to the front face, and the entire appearance of the dam is one of strength.

*c* Concrete will contract in setting and form cracks. In order to control the position of the cracks to prevent them from weakening the dam, radial contraction joints were located every 80 ft. along the length of the dam. The dam was therefore really built up of 80 ft. keystone concrete blocks, and the writer considers it advisable to use contraction joints in all high or long dams. These contraction joints may increase the initial leakage, but after the reservoir has been drawn down somewhat following the first filling and when the dam is at a low temperature, grout may be forced into all joints and leakage cut off.

*d* Although a drainage system is advisable in a gravity dam to prevent uplift due to hydrostatic pressure, it is not so necessary in the arched type of dam. One was provided, however, in the Spaulding Dam, consisting of two parallel rows of holes running vertically from top to bottom of the dam and to bed rock.

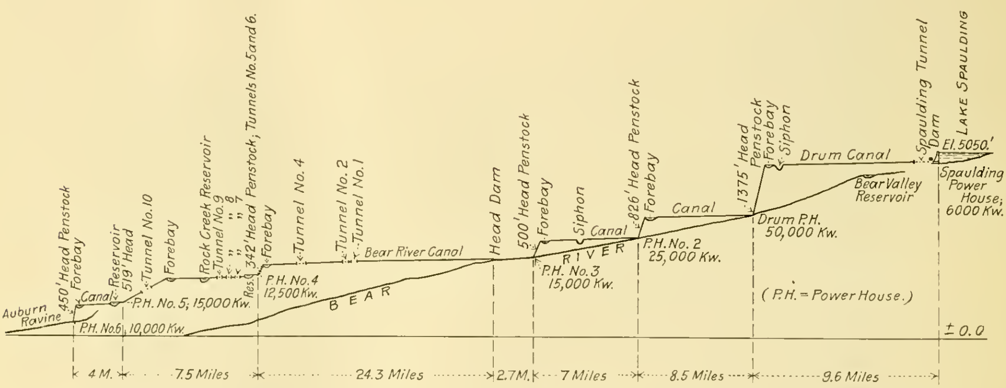



Fig. 2 Profile Showing Locations of the Various Developments on the South Yuba and Bear Rivers

A drainage tunnel was built in the dam following generally parallel to bed-rock, and a discharge tunnel connects with this tunnel to the rear of the dam. The main discharge tunnel from the reservoir is about 70 ft. elevation above the bottom. At an elevation of 100 ft. above this, a second outlet tunnel was built connecting with the first tunnel through an incline rise and giving in effect a gate tower with two openings. Near the upper end of these tunnels were placed 6 ft. steel butterfly valves, connected with the main tunnel by appropriate steel tapers.

At a distance of 694 ft. from the point of convergence of the upper tunnel rise and the original tunnel, a concrete bulkhead was placed, and a new tunnel was driven outward. The whole of this main tunnel to the gates was concrete lined and the last 120 ft. was reinforced sufficient to carry the total pressure that would exist with the reservoir level at 300 ft. in the ultimate dam.

After rising 13 ft. the lined tunnel enters a steel taper, which emerges into the operating chamber and ends in a cast steel manifold, to which are attached two 36 in. Allis-Chalmers pressure regulating valves on the side and a 72 in.

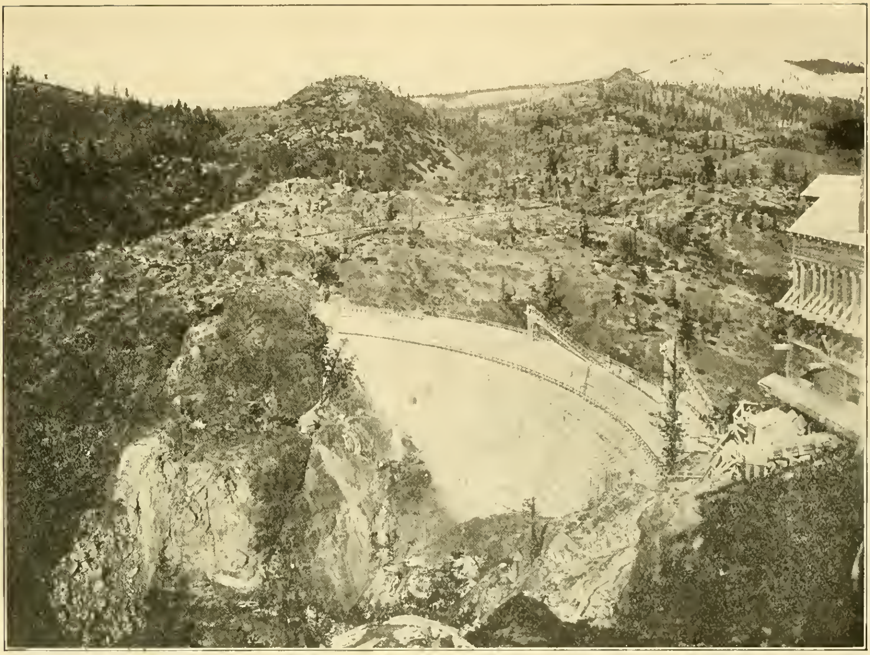


Fig. 3 Downstream Face of Spaulding Dam, Showing Steps and Bond Rails Provided for Raising Dam to 300 ft.

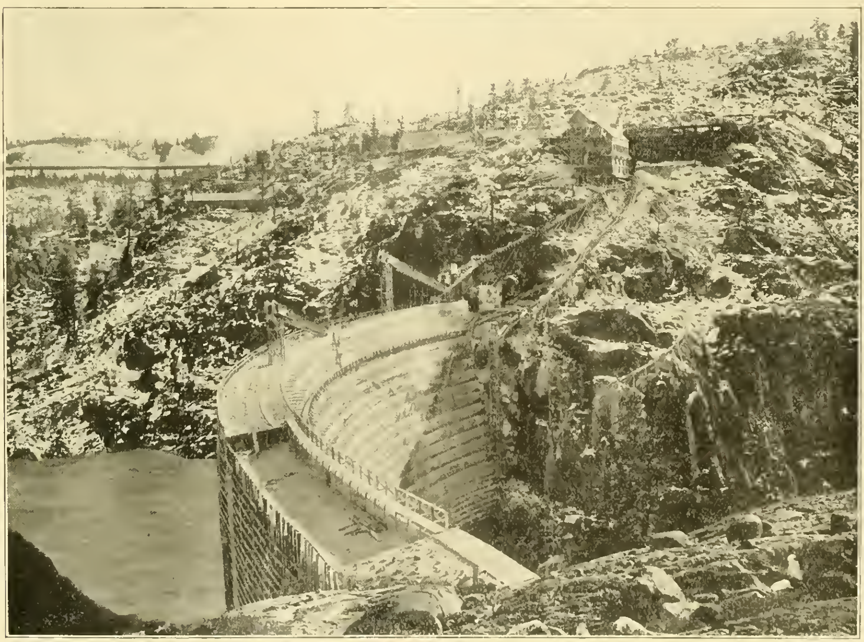


Fig. 4 View of Spaulding Dam Completed to Height of 225 ft., Showing Arch, Spillway and Concrete Plant

butterfly valve on the end. A variable head two runner turbine will later be extended beyond this butterfly valve, but at present the valve dead-ends this taper pipe while the water is drawn off by hydraulically-operated pressure regulators which each have a 36 in. clear opening, guarded by a 48 in. butterfly valve for emergency and repair purposes.

The valve closing the 36 in. port opening is a "mushroom" shaped or conical disc valve, rising up into the stream and being operated by a shaft connected to a disc of slightly larger area in a chamber above to which pressure is applied or withdrawn as needed. By turning handwheel on a screw thread of the shaft extended up through a stuffing box, the attendant can lock the gate at any position according to the flow required.

The valves discharge into steel draft tubes, imbedded in concrete, which turn the water out horizontally into a surge pit below the level of the main tunnel. They are now operating under a static head of 140 ft., and the hollow cone of water shooting out through the gate opening has a velocity of 93 ft. per sec., with no valve vibration.

It is proposed to install later at this place a turbine and generator, consuming about 5000 kw. from the static energy of the impounded waters as they are drawn into the Drum aqueduct, so that the turbine will become the control gate and the power now lost will be sent to the transmission system.

From the Spaulding tunnel, the water is carried 8.5 miles to Drum forebay by 7½ miles of earth canal, 2602 ft. of flumes, and 3600 ft. of siphons. The canal system begins at a small elevation above the South Fork of the Yuba River and follows the mountain side, swinging into the head waters of the Bear River and thence along a light grade of 1 ft. per 1000, finally coming to the end of a spur 1375 ft. above the Bear River, where the forebay is perched.

The length of canal is 39,631 ft., having five sections (in all 2602 lineal ft.) of box flume built at sharp ravines encountered in the length of canal. The canal averages 11 ft. in the bottom width, and 7 ft. in depth, with side slopes of ½ to 1 and 1 to 1, depending upon the formation. The ultimate capacity will be 350 cu. ft. per sec. with an average of 7 ft. depth of water. The canal is broken in two places where siphons are used. The first siphon is a combination of 96 in. wood stave and 84 in. steel tube passing around the Tahoe Forest Reserve, and having a length of 1868 ft., with a maximum head of 237 ft. The second or Drum siphon crosses a draw just before reaching the forebay; it has a length of 1888 ft., is 102 in. in diameter, and has a maximum head of 128 ft. Altogether, the canal required 8511 linear ft. of masonry rock wall and 16,313 linear ft. of dry rubble wall.

The Drum forebay is a large regulating reservoir, gouged out of the top of a hill having an area of 20 acres. It is perched 1375 ft. above the Drum power house and is a lake of 444 acre ft. capacity with a depth of 34 ft. of water.

The forebay dam was constructed entirely of earth and clay taken from within the bounds of the dam. The excavated materials were handled direct by wheel- and fresno-scrapers or were plowed and loaded through traps, or directly by steam shovels into wagons and hauled to the site on the dam. The materials were well worked together by harrowing, rolling and wetting after being freed of all rocks. The latter were used in the 30 ft. rip-rap facing of the inner slope.

After the completion of the forebay dam, which is 230 ft. wide at the base and 54 ft. high at its maximum section, and

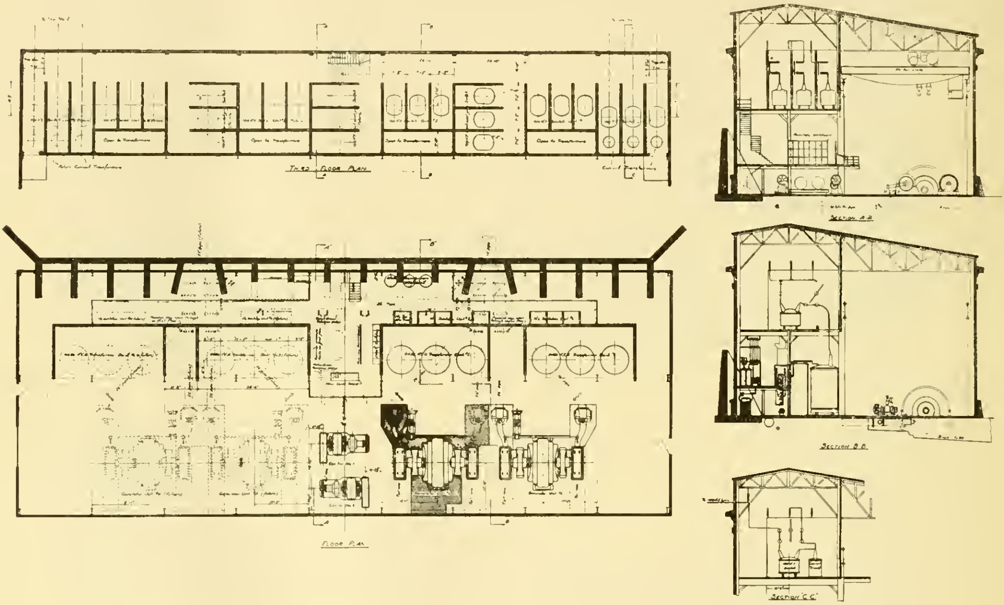


Fig. 5 Details of the Drum Power House, Showing Arrangement of Equipment

contains 266,219 cu. yd. of materials, the bottom and sides were puddled with a good quality of clay found within the enclosure.

The spillway is just back in the canal from the forebay. It is 75 ft. in width. A maximum depth of 1.75 ft. overflow would be required to care for 400 sec. ft.

The waters of the forebay are brought to the power station through a steel pipe 72 in. in diameter which will ultimately be duplicated. This line is 72 by $\frac{1}{4}$ in. riveted steel at the intake, diminishing to 52 by $1\frac{1}{4}$ in. at the power house where the static head of water is 1375 ft. The length of this penstock is 6282.2 ft., having a net weight of 2,920,000 lb.

The penstocks terminate in cast steel Y-pieces, each branch being again divided by secondary Y-pieces. The piping is so arranged that three units may be fed from either penstock. The usual method of operation will be with each penstock supplying two main units.

The main gate valves are of cast steel construction, with single parallel faced discs arranged to withstand pressure from either direction. They have 36 in. openings and are operated by reversible impulse water motors. The special fittings are all of cast steel, while the straight connecting pipes are of riveted steel. The connecting pipes were fitted in place after the Y-pieces and nozzle bodies had been set, and thus perfect alignment of all parts was secured without forcing any part into place with the attendant possibility of setting up stresses in the parts other than those caused by the water pressure.

At Drum power station, on the south bank of the Bear River, a site for a power house was secured by sluicing 40,000 cu. yd. of hill slope and finally blasting into bed rock for a site 100 ft. by 500 ft. long.

The erection of a reinforced concrete and steel building to house four 12,500 kw. generators was completed in November 1913. The initial installation of two 12,500 kw. generators was made and the same were "thrown" into service November 26, 1913.

The main water wheels are of the single jet impulse type and each develops a maximum of 10,000 h.p. at normal speed of 360 r.p.m. It would be difficult to obtain a greater output at this speed and head with high efficiency. The wheel centers are of the double disc type and the buckets are bolted to the discs with the "chain" arrangement.

The governors, which are of the oil pressure type, actuate the deflecting nozzles. The governing is simple and may be operated at any desired speed with perfect safety. The size of the jets is controlled by needle valves which are operated by motors controlled from the switchboard. With a little attention on the operator's part, this combination permits very good economy in the use of water and very good governing with a high degree of safety and simplicity.

Special attention was given to securing a low temperature rise of the main generators, and to devising a rotor construction which would withstand the high stresses set up under runaway conditions. Exceptionally good ventilation is secured by enclosing the generators and bringing all the air into the machine from outside the building. A rotor of great strength is obtained by building up the hub of the rotor of steel discs. Pressing these hubs on to the shafts was avoided by placing the entire hub in a tank of water which was brought up to the boiling point and held there until the rotor was thoroughly heated. This treatment expanded the bore of the rotor by about 20 thousandths of an in. The shaft, which was 8 thousandths larger than the bore of the rotor at normal temperature was simply lowered into the rotor, there being about 12 thousandths to spare. The water wheels were placed on the shaft by the same process. The assembled revolving parts weigh about 83 tons. The flywheel effect of these parts is over 1,750,000 lb.-ft. squared, and the energy stored in them when running at normal speed is over 38,500,000 ft.-lb.

A double circuit 110,000 volt transmission line is provided on steel towers, of which there are 730 in all in place. The initial single circuit extends 110 miles westerly from Drum power house to Cordelia sub-station, which is the load center of Pacific Service. From this point, the power is distributed radially at 60,000 volts to the cities and valleys

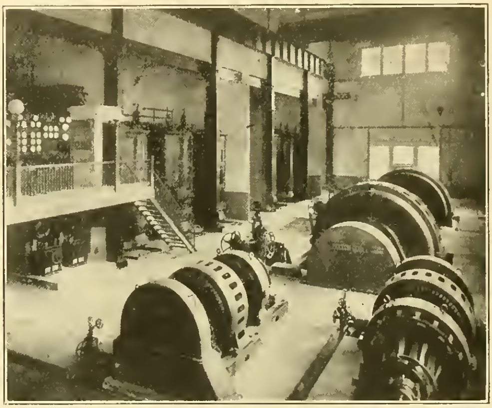


Fig. 6 Interior View in the Drum Plant

surrounding the bay. The standard spacing of towers is 800 ft. centers, with 30 ft. minimum ground clearance, requiring a height of tower of 78 ft. to top cross arm and 82 ft. over all. These towers themselves are of three weights, for straight line work, for spans up to 1500 ft. or angles up to 15 deg., and for use on dead ends and angles over 15 deg. The maximum size of conductor for which they are designed is 4/0 copper. At the present time, the one circuit is made up of 51 miles of 3/0 seven strand copper and 59 miles of 266,800 c/m 19 strand aluminum cable. The longest span is 4056 ft. at Greenhorn Gulch above Colfax.

The Cordelia sub-station located at the end of the Drum-Cordelia 110,000 volt transmission line was constructed in 1913 for the distribution of the 60,000 volt circuits of the Pacific Service.

## DISCUSSION

F. H. Varney asked what velocity the water wheels developed in case they lost the load.

J. P. Jollyman [1] said that the speed of these generators is 360 r.p.m. The velocity of that point on the bucket upon which

[1] Electrical Engineer Pacific Gas & Electric Co., San Francisco, Cal.

the center of the jet impinges is about 46 per cent of the velocity of the jet itself; and in the event of the loss of load other than friction (when of course the wheel will speed up) the speed will reach approximately 100 per cent over normal speed. That is about the limit of the overspeed that can be reached. It is probable that on a unit of this kind 90 per cent of overspeed would be the limit. As the speed goes up, there is a certain amount of interference between the buckets and the jets themselves. However, it was considered in the Drum plant that 100 per cent overspeed might possibly be reached, and the generator was designed so it might operate at this speed without any stresses exceeding the elastic limits, so that in the event of a runaway, no part would be deformed—an important consideration.

The generators were tested in the factory to double speed. That is something that is not always done, although the requirement is one that should be made and met to insure safe operation under all conditions. In some places, in order to take every precaution, this double speed test is made in a deep pit, and the machines are usually operated on a vertical shaft, and if they go to pieces they simply damage the sides of the pit. In the case of our machine, the builders (the Westinghouse Electric and Manufacturing Company) were so sure of their designs and workmanship that they tested the machine at double speed in a horizontal position above the floor.

When the machine is operated at excess speeds, the centrifugal forces become very high because at normal speed the peripheral velocity of the rotor is high, being in our case about 12,000 ft. per min. The centrifugal stresses are so high that it is difficult to maintain the rotor tight on the shaft, and cases have been known where rotors have loosened on the shaft at runaway speed. The hub of the rotor was bored .008 in. smaller than the shaft. Any less allowance might permit the rotor to loosen at double speed, and it is necessary therefore to have the rotors pressed on just as tightly as it is practical to handle them. The factory estimated that 750 to 1000 tons pressure would be required to force the rotor on the shaft, the fit being made in four steps of different diameters. In other words, of the total of about 44 in., the press would have to force the rotor ahead about a quarter of that distance. We thought it more expedient to heat the rotor and shrink it on, as this would avoid any damage to the shaft itself and any possibility of getting the rotor stuck, besides obviating the necessity for a press to give a thousand tons pressure.

The units in one of the Big Creek stations of the Pacific Light & Power Company are very similar to these units, in fact, they are almost identical, and I understand that in pressing the hubs in some of their shafts, this company had some little difficulty in handling the work. They had a very elaborate press, and took quite a long time to perform this work. As I remember, the third day from the time we started, the rotor was on the shaft. The entire water wheel with the buckets on was also heated in the same manner. These wheels could undoubtedly have been pressed on with a very moderate pressure, say, 200 tons, as the fit allowance was much smaller than the hub of the rotor.


FIG. 7 CONSTRUCTION VIEW OF THE 96-INCH WOOD STAVE PIPE ON THE TAHOE SIPHON

The rotor is practically solid, and the object of this is twofold, to get the maximum strength, and to obtain the maximum amount of fly-wheel effect consistent with the amount of space occupied. In other words, we consider it a great advantage to get as much fly-wheel effect as possible without actually increasing the size of the machine. The fly-wheel effect of the rotor is about 1,750,000 sq. ft. and the stored energy is about 33,000,000 ft.-lb. or 1000 h.p. for a minute, and to bring the rotor from rest to full speed or stop it from full speed would require the application of 1000 h.p. for one minute. That is a considerable amount of stored energy.

In governing this plant, we are able to hold the speed within one-quarter cycle of the speed we term normal, and that is very close governing we think for so large a system. We have many fluctuating loads, although the fluctuations in the total load balance up to a remarkable extent; three or three and a half or four per cent is the maximum variation that we receive on the system as a whole. That may be 100 per cent on the governing machine or on the particular unit that is governing; but on the system as a whole three or four per cent from one minute to the other will cover the variations in load. The minimum load is roughly 40,000 kw., and the maximum load is 110,000, and this year it will probably

J. P. Jollyman said that the essential requirements in the design of a bucket on an impulse wheel are that the water be turned and discharged at as low a velocity as possible so as to absorb the maximum energy, and that the bucket enter and leave the stream in somewhat the same manner that the teeth on a gear enter and leave those on a rack. As a tooth on a gear wheel rolls into one on a rack, the back of it must not interfere with the next tooth on the rack, and that principle must be observed in water-wheel practice. In other words, as the bucket gets into the moving stream the back of the bucket must not touch the water that is cut off by the face.

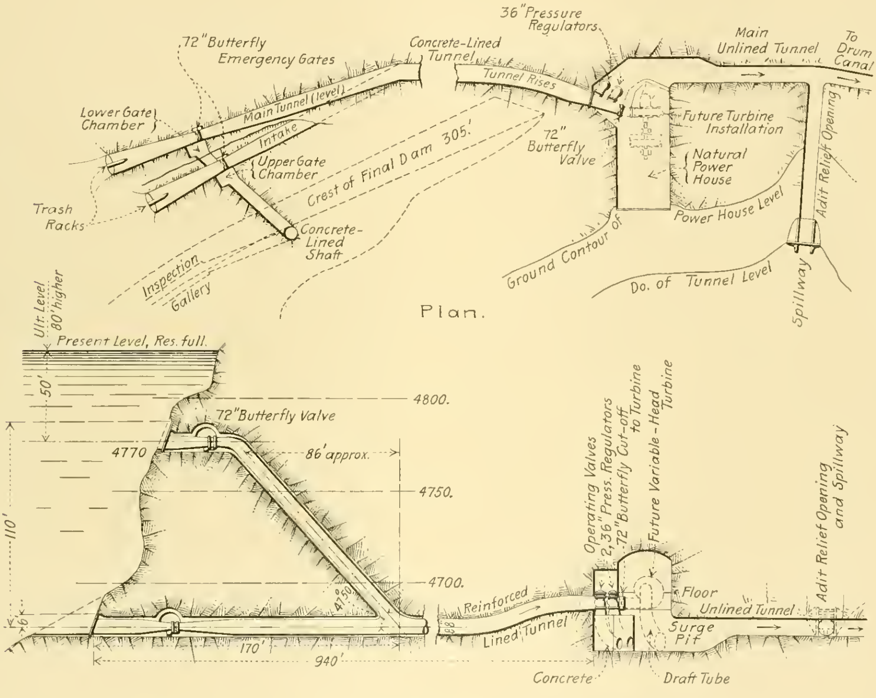



Fig. 8 Details of the Upper and Lower Intakes at the Spaulding Dam, Showing Gate Chamber

reach 125,000. The variation from one hour to another is taken up by properly adjusting the loads on different units, but only one unit in one water wheel plant actually governs.

Thomas Morrin said that some three or four years ago several engineers called on W. R. Eckart, Sr., who had then practically finished the development of the face of the bucket and had turned his attention to the back. Mr. Eckart had found from a demonstrating apparatus that the bucket in use up to that time carried what we call in steamboat parlance, "dead water" on account of the form of the back of the bucket which offered a material resistance.

The principle of back design has been very much emphasized in the past few years. Mr. Eckart was one of the first to develop the idea and there are also others who have worked along these lines.

There are other requirements which of course must be met. The bucket must catch all of the water on the wheel. This limits the minimum number of buckets to probably 15. The Drum wheel has 17 buckets. If you have less than 15 buckets, all the water will not be caught.

The attaching of the buckets to the disc is also an item of very considerable importance, in view of the manner in which the stresses on the attachment vary. If the bucket is running free from the jet, it is acted upon by centrifugal forces only, which tend to throw it off the wheel. When

struck by the jet, the bucket is acted upon by a combination of tangential and centrifugal stresses, which may cause a reversal of stress on some of the attaching bolts. The reversing stress is naturally very hard to take care of, being a hammering effect first in one direction and then in the other. Reversing stress has caused a good deal of trouble in some of the wheels where the design of the attachment has not been properly worked out.

F. H. Varney said that he understood that at different times more or less trouble was experienced in plants such as described from erosion and sand-blast action and so forth. He asked Mr. Jollyman what had been done in the Drum to overcome that action, and also what classes of metal are now used for the water wheels, what metal the buckets and discs are made of and what metal the buckets are held on with.

J. P. Jollyman answered that in some of the older designs of water wheels, corrosion which has the appearance of sand-blast action or pitting has taken place usually at the bottom of the lip of the bucket where it first cuts into the jet, and the buckets have been honeycombed and eaten away. It was thought for a considerable time that this was due to sand in the water; but the same action took place in some cases where there was no sand. Where the water came from settling reservoirs and was positively clear, the same erosion was found in some cases. Then it was thought that possibly air in the water, being liberated at this point, was causing the erosion. The principal cause was finally decided to be improper design. If there is interference between the back of the bucket and the jet, in other words, if the back of the bucket presses against the jet instead of keeping away from it or if in the course of the bucket's path through the jet, pressure is put on a point and then released suddenly, pitting will take place. I believe that most engineers now concede that pitting can be very largely avoided by so designing the parts, that the water will be deflected uniformly, and no very sudden change in the direction or rate of motion of the water allowed to take place and that there should not be any interference between the back of the bucket and the jet. With those precautions observed, there seems to be very little honeycombing, pitting or wearing.

A certain amount of wear on the face of the bucket is unavoidable, but with buckets of good design this wear is very small. We have had wheels at DeSabla operating under 1531 ft. head (that at Drum is 1375 ft.) for eleven years and they do not show very much wear. The original buckets are still on the wheels and have been used almost constantly. Those buckets and the buckets on the Drum wheel are cast steel. At one time it was thought that buckets of bronze would wear better than buckets of cast steel, but I do not believe that the material is as important as the design. The pitting is more easily and more correctly explained by incorrect design than by chemical action or the material. In places where a large amount of sand is carried by the water, I think it is probable that bronze has a slight advantage over cast steel. The bronze seems to have something of the effect of rubber which is very slightly eaten away by sand-blast as compared with a piece of steel. Bronze seems to have a certain yield or tendency to hold together that cast steel does not have.

F. H. Varney asked whether vanadium steel had been used.

J. P. Jollyman said that he did not believe so. He thinks the buckets are cast from open hearth steel. The wheel centers on the Drum machines are cast steel. They had some wheel centers made of steel similar to that used in armor plate; but they believe now, with the increased knowledge of what may be done in the way of attachment, that it is not necessary to have a steel harder than nickel steel or good open hearth steel for these conditions. For very much higher heads than occur in present practice other steel may be necessary.

Wm. J. Davis, Jr., asked how the speed regulation governors of the Drum Power House are set.

J. P. Jollyman answered that the drop in speed from no load to full load on the governors is adjustable. With one unit governing the system they adjust that for zero drop in speed. In other words, the unit tends to maintain a uniform speed at any load. Of course if more than one unit is required to govern, then both must be given a small drop in speed, about one or two per cent, in order to let them operate in parallel and both govern. As a matter of fact the Drum units are of sufficient capacity to govern alone; and with one unit governing we set the governor so it gives the same speed at full load as it does at normal. The whole system is then governed.

Wm. J. Davis, Jr., asked what is the effect of the setting of the governors on the parallel operation of the Drum Power House with the steam plant in San Francisco. He thought it would be desirable to have the steam plant take the fluctuations of load, and the water plant a constant load.

J. P. Jollyman said that would be the best arrangement for operation. The fact is that the transformer capacity between the hydro-electric system and the steam plant is limited and it is hardly possible to let the steam govern the whole system for fear of overloading the transformers. The San Francisco steam plant has a capacity of 40,000 kw. The transformer capacity between the hydro-electric and the steam is only 9000 kw. They do not attempt to carry the whole of the San Francisco load from transmitted power. In fact their system at the present time of the year could not do that. It is rather the better condition to govern by steam and use all the water. As a matter of fact, to do that would throw fluctuations into this plant of greater amount than its present capacity. With a zero drop in speed for changing load, the Drum governing machine tends to take all the fluctuations out of the system; and the operators of the steam station have to watch the loads on the connecting cables very closely to assist in the governing, to prevent the overloading of these cables.

The parallel operation of the system as a whole is very satisfactory indeed, there being no reciprocating units used but only rotating machines. The steam turbines and the water wheels are all of uniform rotating speed. There is no surging between one unit and another and no tendency to drop out of step.

# RECENT DEVELOPMENTS IN STEAM-ELECTRIC GENERATING STATIONS

BY JOHN HUNTER, ST. LOUIS, MO.

Member of the Society

*The meeting of the St. Louis Local Section on October 28, 1914 was a joint meeting of the Associated Engineering Societies of St. Louis, held under the auspices of the St. Louis Section of the Am. Soc. M.E. at which an address was delivered by John Hunter, chief engineer of power plants of the Union Electric Light and Power Company of St. Louis, Mo. Mr. Hunter summarized the equipment of the large generating stations in New York, Boston, Philadelphia, Washington, Detroit, Chicago, Milwaukee and St. Louis, and traced in an interesting manner the phenomenal development in power generation as exemplified in these plants. Some extracts from the address are given herewith, as abstracted from a report of the meeting that appeared in Power, December 22, 1914.*

At present there are 15 different public-service corporations supplying power to the five boroughs of the city of New York. The New York Edison Co., operating the great Waterside stations, dates back almost to the beginning of the electric-light industry. The old Pearl Street Station, the first Edison electric-lighting station in New York, was built in 1882. Up to the advent of high voltage, alternating-current transmission and distribution, there were numerous steam stations of the non-condensing type for direct-current generation built here and there about Manhattan Island. The first plant of any considerable size was Waterside station No. 1, built in 1900 and designed for sixteen 3500-kw. alternating-current generators driven by vertical compound engines. In 1905, after eleven of these units had been put in, the equipment was completed by the addition of three 5000-kw. vertical turbines and two 10,000-kw. horizontal turbines. In 1911 and 1912 four of the engine units were removed and three 20,000-kw. vertical General Electric turbine units installed. At the same time one of the 5000-kw. turbines was rewound for 9000 kw. The total capacity of the plant is thus 123,500 kw.

This station was rapidly outgrown and Waterside station No. 2 was built in 1909. It adjoins the No. 1 station and together, so far as operation is concerned, they are practically a single station and form the largest steam plant in the world, having a combined capacity of about 215,000 kw. The No. 2 boiler house contains ninety-six 650-hp. Babcock & Wilcox boilers operating at 200 lb. pressure with 125 deg. superheat. The boilers are in eight rows across the boiler house, six in a row and on two decks.

In the turbine room there are six 8000-kw. Curtis turbines, two 8000-kw. Westinghouse turbines and two 14,000-kw. Curtis turbines. Each of the Westinghouse turbines drives a twin generator, one 25-cycle, 6600-volt, and the other 60-cycle, 7500-volt. Either is used as required; they run at 750 r.p.m. The main generating units are equipped with surface condensers, utilizing salt water from the East River for cooling. To provide against a shortage of coal in case of strike or delayed deliveries, the company has a storage yard at Shadyside, on the New Jersey shore, capable of stocking 200,000 tons.

The Fifty-ninth Street station of the Interborough Rapid Transit Co., which carries the subway load, is of special interest in that it has five of the largest exhaust-steam turbines in existence. The original installation was completed about 1903 and contained nine 700-kw. Allis-Chalmers (combined double horizontal and vertical, 11,000-volt, 25-cycle). Later, about 1905, three 1725-kw. Westinghouse turbines were installed. Each of these engines had two horizontal high pressure cylinders 44 in. diameter and two vertical low pressure cylinders 88 in. diameter, with a common stroke of 60 in. The original boiler installation was fifty-two 600-hp. Babcock & Wilcox water-tube boilers, with space for 20 additional boilers; eight more were eventually put in.

Due to the rapid increase in the demand for electric current from this company, the capacity of the station had to be increased. Five low-pressure Curtis turbines of 7500-kw. capacity were installed between and to one side of the reciprocating engines without purchasing additional real estate. The method used in starting up the combined engine generator and low-pressure turbine is simple. Excitation is applied before starting, then, when brought up to speed, the machine is synchronized in the usual manner. While starting in this way, the induction generator connected to the low-pressure turbine acts as a motor until sufficient steam passes through the engine to carry the turbine above synchronous speed, when it immediately becomes a generator and picks up the load. The leads of the turbine are tied in solidly to the main generator leads through knife switches which are never opened.

The net results obtained by the installation of the low-pressure turbines in this station have been summarized as follows:

- An increase of 100 per cent in the maximum rating of the plant.
- An increase of 146 per cent in the economic output of the plant.
- A saving of approximately 85 per cent of the condensed steam for return to the boiler.
- An average improvement in economy of 13 per cent over the best high-pressure turbine results.
- An average improvement in economy of 25 per cent (between the limits of 7000 kw. and 15,000 kw.) over the results obtained by the engine units alone.
- An average unit thermal efficiency between the limits of 6500 and 15,000 kw. of 20.6 per cent.

In the Seventy-fourth Street station of the Interborough Rapid Transit Company, there are 64 Babcock & Wilcox boilers and the generating equipment comprises eight Allis-Chalmers 7500-kw. combined horizontal and vertical Corliss engines, similar in all respects to the original installation in the Fifty-ninth Street station, and one 7500-kw. Westinghouse horizontal turbine of the same rating as the engines.

Abstract of paper presented at the St. Louis local meeting of The American Society of Mechanical Engineers, on October 28, 1914

The growth of this company's business again required additional capacity from its generating stations and it has now decided to remove four of the engine units and install three Westinghouse turbines, each of 30,000-kw. capacity. These turbines are cross-compound units. The high pressure element is a single-flow turbine operating between steam-boiler and approximately atmospheric pressure. On leaving the high-pressure cylinder, the steam goes through a receiver separator and then into the double-flow, low-pressure cylinder. The high-pressure end operates at 1500 r.p.m. and the low-pressure expansion end at 750 r.p.m.; both ends are controlled by a single governor driven from the high-pressure spindle. The two generators are electrically tied together, therefore no governor is needed on the low-pressure end. The guaranteed water rate is 11.27 lb. per kw.-hr. Steam enters the center of the turbine through two openings and then divides, one half going each way to a condenser at each end.

The Philadelphia Electric Co. has two main generating plants, stations A-1 and A-2. Station A-1 is equipped with turbines varying in size from 750 kw. to 15,000 kw. For this station a 35,000-kw. General Electric turbine is now being built. While it is 5000 kw. larger in capacity than the large Westinghouse cross-compound turbine, it is contained in one unit and involves special characteristics recently developed by the General Electric Co. To permit of greater mechanical stability and to provide greater area in the low-pressure end, the casing is divided into two parts with a bearing between. The revolving field is an enormous steel forging, with milled slots, similar to small machines. The armature frame is cast in two halves, each of which represents about the limit of casting and transportation possibilities. The turbine and generator are mounted on a common base, thus constituting a single generating unit, in this respect surpassing anything else heretofore attempted.

Delray plants Nos. 1 and 2 of the Detroit Edison Co. are four miles southwest of the business center of Detroit, on the banks of the Detroit River. No. 1 station, built in 1904 and containing four 3000 kw. units, now has four 8000-kw. Curtis turbines. No. 2 station, built in 1908, has three 14,000-kw. and one 15,000-kw. turbines, making the turbine rating of the two plants 89,000 kw.

The original design of the No. 1 plant included a surplus of boiler capacity for the purpose of permitting the four original 3000-kw. Curtis turbine sets to operate noncondensing; the exhaust steam was to be supplied to salt refiners in the vicinity for evaporating brine. Twenty-four 500-hp. Stirling water-tube boilers were installed, set in four batteries of six each. Each boiler contains 4834 sq. ft. of heating surface. The second bank of tubes forms the superheater with an area of 1500 sq. ft. and superheating to 600 deg. fahr., or 200 deg. fahr. above the normal temperature of the steam at 210 lb. per sq. in.

The first four turbines in station No. 1 were run condensing. The plan for supplying exhaust steam to the salt refiners was never carried out because the company's load had so increased that it was found necessary to install an additional 3000-kw. unit; this was done without increasing the boiler equipment. The first four 3000-kw. machines of 1904 were replaced in 1911 by 8000-kw. units of similar type, equipped with Worthington 16,000-sq. ft. surface condensers of the base type.

The No. 2 turbine room has three 14,000-kw. and one 15,000-kw. vertical Curtis General Electric turbine units, which, like the machines in No. 1 turbine room, furnish 4600-volt, 60-cycle, three-phase energy. The turbines are ventilated by forced draft and the dampers are so arranged that air can be taken from the engine room and delivered to the outside, or, as is desirable in winter, the outside air can be taken into the machines and delivered to the engine room.

Of special interest in connection with the Delray plants are nine big double-fired Stirling boilers in the No. 2 power house, each having a rated capacity of 2365 hp. The normal output is 7000 kw. in regular service and they have been drawn upon for 11,000 kw. during short periods. All are equipped with Taylor stokers, which have a nominal area of 300 sq. ft., with a heating-grate ratio of 79 to 1. The steam pressure carried in this plant is 205 lb., with a 150 deg. superheat. This is one of the first stations to develop high superheat. The original steam fittings were cast iron and had to be changed to steel after five years, weakness in the iron having developed. The superheaters are mounted between the boiler tubes proper.

Each of the 54-in. steam drums has eight $4\frac{1}{2}$-in. safety valves besides four 3-in. valves on the superheaters. The advantages in the use of these large units are found in a decreased cost per horse power of rating; a lower radiation loss per unit of capacity, hence a higher efficiency, and they occupy smaller area per unit of output. Repairs on these large units are not excessive and do not exceed the usual cost per horse power with small-size units. The combined boiler and furnace efficiencies obtained run from 80 per cent at 75 per cent rating to 76 per cent at 200 per cent.

With the city's phenomenal growth in demand for electric energy, the Detroit Company has under construction a 100,000-kw. plant at Connor's Creek, which is at the opposite end of the city near Lake St. Clair. This plant is expected to be completed to take the fall load of 1915.

By far the greater part of the electrical energy generated by the Commonwealth Edison Co., in Chicago, is produced at the Fisk Street and Quarry Street stations, which are on the south branch of the Chicago River. The engine room of the Fisk Street plant is 630 ft. long and was originally designed for fourteen 5000-kw. vertical Curtis turbine units. The first unit was installed in 1903, but later it was decided to use 12,000-kw. units instead of 5000. One of the 12,000-kw. units had been installed when the advance in the art led the company officials to decide that the last four units should be of 20,000-kw. capacity, or larger, and of a horizontal type. Of these two are already installed, one a General Electric 20,000-kw. and the other a Parsons 25,000-kw. turbine.

The boiler house of the Fisk Street station was originally designed for fourteen batteries of eight 500-hp. boilers, and ten of these batteries, comprising eighty boilers, are already in use. The remainder of the boiler house will be filled with four batteries, each of four boilers and each boiler having 12,250 sq. ft. of heating surface, with an equipment of economizers and induced draft fans with which, it is anticipated, the boilers can be worked at 200 per cent of rating. The combined generating capacity of all the units at Fisk Street is 165,000 kw. When running at full capacity the station will consume nearly 2000 tons of coal a day, and nearly 200 tons during the maximum or peak hour. The number of heat units required to generate a kilowatt-hour with the old equipment was approximately 28,000; with the new equipment it is something less than 20,000. This would be 2 lb. of coal at 10,000 B.t.u. or 1.43 lb. at 14,000 B.t.u.

The great increase in the business of the Commonwealth

Edison Co. made it necessary to build the Quarry Street station in 1908. The two stations are operated together as one electrical generating station, being connected by tie lines in two tunnels.

Arranged in two rows parallel to the turbine room are eight 500-hp. water-tube boilers for each generating unit, or 48 for the entire station. The original boiler setting at Quarry Street was a departure in furnace design in that the furnaces were placed under what is usually considered the rear header. In other words, the slope of the tubes was up and away from the furnace rather than the reverse. The advantage sought was in the long combustion chamber, expanding in volume, which made for more complete combustion of the fuel and an increase in boiler efficiency. These boilers were equipped with horizontal passes. After a time it was found that the maintenance costs were running high, and it was decided to equip the last six of the boilers with standard settings, although at the same height as the other; this gave a larger combustion chamber than is the usual practice. Eight boilers are independently connected to each of the six turbines, although cross connections are available in case of emergency. Quarry Street was the first station in the United States to install centrifugal boiler feed pumps.

The rate at which the business of the Commonwealth Edison Co. was increasing made it evident in 1910 that the Fisk and Quarry Street stations would be inadequate for the service and plans were immediately made for additional station equipment. The new Northwest Station has been the result. Between 1908 and 1910 the maximum load of the system grew from 117,370 kw. to 182,600 kw., an increase of $55\frac{1}{2}$ per cent. In 1912 the maximum load had further increased to 200,000 kw. In planning for the capacity of the new station the indications were that for a number of years the increase would average at the rate of 15 per cent per year. This rate of increase, applied to the load of 200,000 kw. in 1912, indicated that the net increase of load during the following five-year period would amount of 220,000 kw.

Accordingly, plans were made for two new power houses of 220,000 kw. each, it being considered advisable to prepare for more than five years' growth. A location was therefore selected which would be suited to the many and great requirements of such an equipment. To supply fuel for an aggregate of 240,000 kw., or 350,000 hp., requires something like 4000 tons of coal per day, or 100 car loads. Inasmuch as the fuel has to be brought 200 miles by rail for the Chicago plants, a reserve supply of even four days, if held in cars, would mean four miles of track room for 400 cars. The coal strikes, which occur quite regularly every two years, however, frequently mean that no coal can be had from the mines for three months. Hence one of the demands of the new plant was that there must be sufficient storage for coal to carry the stations over a three months' interval—that is, storage room for 350,000 tons. The site of the new Northwest station was therefore chosen at a point on the north branch of the Chicago River, several miles from the Fisk and Quarry Street stations, where sufficient acreage for coal storage was available.

The boiler house is so designed and equipped that at no point in the handling of the great volumes of coal that daily passes through it, is it necessary to use manual labor. The boilers are arranged in rows of ten each, facing each other on opposite sides of a common firing aisle, so that one set of firemen and water tenders can look after twenty boilers. Each ten boilers are served by a tile-lined steel stack, 17 ft. inside diameter and extending 275 ft. above the boiler-room floor. When completed the turbine room will be 290 ft. long with the five turbines spaced on 44-ft. centers. The first two turbines are of the vertical Curtis type, similar to those of the Fisk and Quarry Street stations, and are rated at 20,000-kw. capacity, with a steam consumption of 13.45 lb. per kw.-hr. at the most efficient load, namely, 15,000 kw. The additional units for this plant are expected to be of the horizontal type and may run in capacity to 30,000 kw. or more.

# TECHNICAL DISCUSSION

## COMMUNICATIONS UPON ENGINEERING SUBJECTS TREATED IN PREVIOUS ISSUES OF THE JOURNAL

### A RATE-FLOW METER

J. W. Ledoux, in a written discussion on the paper by H. C. Hayes on A Rate-Flow Meter which was published in abstract form in the March issue of The Journal, said that the question of using the difference in pressure at the inner and outer diameter of a pipe bent to a curve has been considered by engineers for a considerable time past, but this paper, for the first time to the writer's knowledge, gives a rational discussion of the elements affecting the flow under these conditions.

Any form of meter of this kind, of course, depends on the true bore of the pipe. As a casting is always subject to considerable variation, machining is resorted to in all first-class forms of Venturi tubes. For Pitot tube measurements, resort is had to traverses and measurement of the diameter of the pipe in place. With the Venturi tube the coefficient of discharge is determined by experiment for a considerable number of sizes, so that the accuracy attainable at the present state of the art for ordinary velocities can be counted on with probably $1\frac{1}{2}$ per cent. With Pitot tube measurements, the calibration of the Pitot tube itself is carefully determined by experiment in the same way, so that when the traverse of the pipe is once made, the results with a Pitot tube in the center of the pipe can be counted on for all mean velocities within the range of the apparatus, say from half a foot per second up to ten or more ft.

The simple formula for the flow in an inferential meter of any of these types including that described by Mr. Hayes is

$$H = c\ v^n$$

in which

v is the velocity through the pipe or meter.

c is a constant coefficient.

H is the head.

For any form of Venturi tube, orifice, or Pitot tube, n becomes 2 and when c is once determined by calibration, it is used without change for all meters of the same class.

For the V notch weir n becomes 2/5.

For the rectangular weir about 2/3.

For Mr. Hayes' device n appears to be 2.2, but the question is whether, if his experiments were sufficiently extended, this value of n would not approximate 2. If this exponent cannot be counted upon as a constant under various conditions and sizes of vortex meters, the ap-

paratus cannot be considered satisfactory as a commercial proposition.

At first sight, it would seem that the large deflections for given velocities as compared with the other two devices would be an immense advantage, and that is true providing we had to do with mean velocities below 1 foot per second only, but the ordinary Venturi or Pitot tube meter is often required to give its greatest accuracy at velocities considerably above 1 foot per second, and for a Venturi tube with a ratio of two to one, the deflection for only 6 ft. mean velocity corresponds to about 10 ft. of water head, or say 10 in. of mercury head, and a meter requiring much more than this becomes cumbersome in size.

Mr. Hayes states in his Par. 17 that "Such a meter should not be greatly affected by fluctuations of pressure such as are always produced by feed water pumps, for the inertia of the vortical mass will serve to steady the gauge readings much as the fly-wheel does the motion of an engine." If that is the case then it is only necessary to use on the small pipes leading from any form of meter to the register, some inertia device of sufficiently large mass of heavier or lighter liquid than that to be measured, but there is a prevailing impression that any form of inferential meter, including the one under consideration, will not measure accurately if there is a violent fluctuation in rate of discharge, a condition that is frequently caused, for example, by a reciprocating pump, which is not connected with a large air chamber. If that is true, the defect obviously cannot be remedied unless the vortical mass can in some manner induce a uniform rate of discharge through the pump. This subject, however, has not been fully investigated.

The heretofore objections to metering water with these inferential types have not been due to the shortcomings of the Venturi tube but to the limitations of the registering devices. Mr. Hayes refers to several well-known devices, some of which depend on cams and others on the movement of shaped floats, and he concludes that the trouble with these devices is the necessity of a stuffing box which introduces so much friction as to interfere materially with the accuracy. The stuffing box, however, is the least of the difficulties, and with well-designed details, the results are approximately as good with the stuffing box as without, because the shaft connecting the inside and outside of the meter register is so small compared with the radius of the rack-pinion or sheave, that this friction is negligible. Any form of cam, however, introduces another kind of an error that is much more serious. Mr. Hayes would overcome all these objections by using the device shown in his Fig. 7 of the March issue of The Journal and of Fig. 16 of his original paper. This principle was investigated by the writer as far back as 1904, after which it was found that Mr. Walter Ferris was really entitled to the priority of invention, although while illustrating the basic principle his disclosure did not show it in a very practical form for commercial use.

According to Mr. Hayes' presentation, the radius of the shaped vessel becomes infinite before the flow has reached zero, and therefore, this particular type of meter has a serious theoretical limitation, which makes it incapable of measuring with the same instrument from the highest to the lowest flows. In fact, it has the same limitations as the type using the parabolic cam, which is vertical to its axis at the minimum velocities.

The flexible tube introduces a very objectionable feature except where there is no pressure in the vessel, when it can be made of rubber tubing with thin walls, but the weight of the mercury in the cylindrical vessel must be externally resisted by some form of contrivance that operates in such a manner that the resistance is proportional to the weight. This means a spring, or a weight with a variable lever arm, or some other equivalent device. Every one who has had to do with springs knows how difficult it is to get them to act according to their theoretical law and retain their properties for any great length of time. Presumably Mr. Hayes would make vessel B of glass and have attached thereto a uniformly graduated scale, which would give true indications of the heights of mercury in terms of velocity within the theoretical range of the instrument.

The apparatus described for eliminating the effect due to temperature is ingenious but probably impracticable for commercial cases, and at any rate, the differences due to changes of temperature are not important in water measurements, because the errors due to the ordinary range of temperatures can be neglected, and where the meter is used for hot water, it can be adjusted for the desired temperature by simply changing the size of the pinion or sheave.

There are a number of ingenious and practical registering devices of great merit in experimental use that have never as yet to the writer's knowledge been publicly described or illustrated, and this is the line of investigation that seems to warrant the expenditure of inventive effort.

In passing, it would seem that Mr. Hayes did not write his article with the idea of having it easily understood by the practical man, familiar with ordinary mathematical processes. The writer has not checked up the mathematical results because it would seem that those with which he is already familiar are more simple and direct. It is always desirable to simplify such discussions so as to be within easy reach of the maximum number of investigators.

On the whole, the writer believes that Mr. Hayes deserves great credit for his effort and accomplishment.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

One of the unfortunate results of the present events in Europe is the fact that many of the engineering societies there have been forced to abandon their usual spring meetings at which valuable papers were formerly presented.

### THIS MONTH'S ARTICLES

In the section on Air Engineering is abstracted a discussion of the advantages and disadvantages of various blowers for cupola service, in which, among other things, the author questions the wisdom of using a single blower for several cupolas of different sizes.

The economy and possibilities of the use of Diesel engines for ship propulsion is discussed, both generally and with reference to data collected by actual experience. The author apparently believes that while a Diesel engine is somewhat more economical than a steam engine, its economy, in view of some other disadvantages, is not sufficiently high to carry with it the promise of materially displacing the steam engine as a prime mover on the high seas.

An abstract of the article on ball-bearings in electric railway cars in Switzerland shows an interesting design of ball-bearing installation, especially on center bearing between the underframe and bogie of the cars.

Two articles are devoted to the subject of boiler explosions. One describes an explosion of a locomobile boiler and shows how an apparently good boiler may become exceedingly dangerous because of presenting possibilities of improper manipulation. The other article shows that boiler furnaces fed with lignite coal, rich in gas, may, under certain circumstances, act somewhat as a gas producer and lead to disastrous explosions.

The article on German progress in steam boiler firing, the beginning of which was abstracted in *The Journal* for March 1915, is continued in abstract in the present issue.

An interesting account of tests on inclined cables is abstracted from the Journal of the Engineers' Society of Pennsylvania. W. H. Phillips, in a paper before the Engineers' Society of Western Pennsylvania, gives some data on a new secret method of heat treatment of gears called the B. P. Process, as well as on heat treatment of railway gearing generally. This paper led to an interesting discussion partly abstracted in the section Engineering Societies. J. D. Berg describes a low pressure steam turbine installation for mill drive, of particular interest both on account of its engineering features and also because it is the only one of that kind in existence in this country and the second installed anywhere.

Alan E. L. Chorlton, in a paper before the Institution of Mechanical Engineers, discusses the question of convertible gas engines and shows the kinds of engines, and conditions, which particularly lend themselves to use with more than one type of fuel. Among other things, the paper describes the Clerk supercompression engine.

Particular attention is called to the paper by Charles H. Lees (Royal Society) on the Flow of Viscous Fluids Through Smooth Circular Pipes, which contains not only interesting formulae but also presents a valuable discussion of the work previously done on this subject.

## FOREIGN REVIEW

**Air Machinery**

ADVANTAGES AND DISADVANTAGES OF VARIOUS TYPES OF BLOWERS FOR CUPOLA WORK.

The article discusses the advantages and disadvantages for cupola service of various types of blowers, centrifugal, rotary, and reciprocating.

The output of centrifugal blowers or fans is dependent upon a definite cross-section of outflow at which they can attain their highest efficiency. If, at the same speed of rotation, the most favorable cross-section of outflow is changed, both the amount of air taken in and that delivered by the centrifugal blower change in accordance with a known law. These changes are considered by the builders of centrifugal blowers and by some foundrymen as an advantage, but there appears to be a prevalence of opinion that really they are disadvantageous because they oppose in an undesirable manner the changing resistances in the cupola.

In regard to rotary blowers (of the Root and similar types) their action in delivering a practically constant amount of air under all conditions, appears to work favorably together with the change of resistances in the cupola.

Previous investigations have shown that as far as the operation of the cupola is concerned, the amount of air delivered and the air pressure are the determining magnitudes for the blower. It would have been of considerable interest, therefore, to find out whether and in how far standardization of cupola blowers is desirable.

In regard to the measurement of air delivery in the case of cupola blowers, many tests have established that anemometers give indications which are too large, and measuring nozzles, indications which are too small. The measurement of air on the basis of pressure differences in a double nozzle does not seem to have been as yet widely introduced in cupola service. Air may also be measured by exhaust gas analysis, but that is hardly suitable for small foundries. The measurement of air pressure as done now does not satisfy even the desire for information as to whether the required amount of air goes through the cupola, but, as soon as we start to measure the air in the state of motion, there will be a greater impetus for more thorough regulation of cupola blowers which can now be effected in a number of ways, for example, by varying the speed of rotation, or cross-section of outflow (of blower or piping).

As regards regulation, centrifugal blowers seem to have an advantage over rotary blowers because the power consumption in the former is within certain limits nearly proportional to the air output. On the other hand, the centrifugal blowers have a disadvantage in that, especially when driven by belting or other indirect transmission, they admit of only a limited variation in the speed of rotation and a certain excess of air has to be wasted by blowing off, which represents a corresponding loss of power and money. We have very little or no information as to the magnitude of

the losses which occur in that or another type of cupola blower as a result of the regulation of air output, which is indirectly proved by the fact that often several cupolas of very different dimensions are served by one blower.

It may be possible that if the losses due to regulation were better known, it would have been found that in the end it pays better to provide each cupola with a separate blower suited to its dimensions; if this were done, there would be a strong argument in favor of centrifugal blowers because of their low space and foundation requirements, ease of location in close proximity to the cupola and their practically noiseless operation.

It must be borne in mind that in a cupola operation it was found to be of great advantage to work with as uniform an air pressure as possible; this is one of the characteristics of centrifugal blowers and makes unnecessary the installation of equalizing air tanks on the cupola, or collectors in the piping. The author believes that in the selection of a suitable blower it would be well, before making a decision, to answer the following questions:

1. Are the variable resistances opposed to the blast in the cupola, such as clogging of the nozzles, hard and loose formation of bed of the charge, variable heights of charge, etc., so well determined in practice that their influence justifies the preference for a rotary blower?
2. Are the losses in power caused through regulation, often amounting to from 30 to 50 per cent of the normal air output, so low that one can operate for years two ovens with one blower large enough to fulfill the requirements of the larger oven, without suffering great losses?
3. Do differences in efficiency and first cost constitute a basis for preferring one or another type of blower, or must the influence of internal resistances in the cupola be also taken into consideration?
4. How can we, in the most certain manner, determine the amount of air passing through the oven and the power usefully required for operating the cupola blower?

(*Vor- und Nachteile verschiedener Gebläsearten für Kupolöfen*, J. Treuheit, *Stahl und Eisen*, vol. 35, no. 4, p. 102, January 28, 1915, 2 pp., *p*).

**Internal Combustion Engineering**

Large Diesel Engined Ships for Marine Navigation and their Economic Possibilities.

The article discusses the economy and possibilities in the use of Diesel engines for ship propulsion.

During the last three years, about fifty sea-going vessels have been either built or laid with Diesel engines as the propelling machinery. Nevertheless, engineers and shipbuilders are as yet by no means agreed as to the economy of this method of propulsion. At first sight, shipbuilders have been strongly influenced by the difference between the thermal efficiency of a triple expansion steam engine amounting to about 14 per cent, and the 38 to 40 per cent claimed for the Diesel engine. In addition to that, three years ago, at the time when the Diesel patents ran out, the prices of crude oil were very low and in this respect the entire proposition looked far more attractive than it does with the present prices of oil, nearly three times as high.

The question of economy of Diesel engined ships has to be considered in the first instance in connection with the kind of fuel for these engines. The main source of the fuel is the Atlantic Coast of the United States, Pennsylvania, Ohio, Texas and the southern states. There are large supplies of oil in Mexico around Tuxpan, but Mexican oil is not very well suited for use in Diesel engines, particularly because of its high asphaltum and sulphur contents. California oil, while available at present, will probably advance considerably in price after the opening of the Panama Canal, and in addition to that, a combination of powerful European interests have lately obtained control of a production of from 300,000 to 400,000 tons of oil per year. As far as sea navigation is concerned, the Russian, Roumanian and Galician oils are not as yet of much importance, especially as the Russian oil is said to be unsuitable for Diesel engines. In eastern Asia, however, large supplies of oil of the Diesel engine quality are available.

Rieppel has found in his investigations on Liquid Fuels Suitable for Diesel Engines that the most convenient are high percentage gas oils and paraffin, but the tar oils and hydrocarbons with a heating value below 9,000 WE (16200 B.t.u. per lb.) and containing asphaltum cannot be directly used in Diesel engines. Of late, however, it has been found that oils with an asphaltum content not in excess of 26 per cent and sulphur content not in excess of 2 per cent and a state of fluidity at 4 deg. cent. can be used in Diesel engines provided they are free from water, mechanical impurities and give no material ash residue. As a rule, crude oil is only in the rarest cases directly suitable and clean enough for use in Diesel engines. It is usually the products of distillation, distilled from temperatures between 150 and 350 deg. cent. (302 to 662 deg. fahr.) that can be used in an engine provided their asphaltum and sulphur contents are not excessive. Distillates of lignite coal tar, obtained particularly by dry distillation of tar, are very convenient for use in Diesel engines. Owing to their high contents of paraffin, these oils, when injected into the working cylinder at a temperature corresponding to a compression pressure of from 33 to 34 atmospheres, form an oil gas which ignites with extraordinary facility. Coal tar, however, because of its low hydrogen content can be burned in a Diesel motor only with considerably more difficulty, and to help that, to the coal tar from 5 to 10 per cent kerosene is added, or the oil is preheated. For sea navigation outside of Germany, coal tar has, however, little importance.

So much for the source of fuel; now as regards the economy and efficiency of Diesel engines as compared with a steam plant of the triple expansion type the following data may be of interest: They refer to two vessels, the Saltburn and the Eavestone, both of the Furness Line. Both are comparatively small vessels of equal length, beam, free board and depth. The weight and machinery is in the case of the steamer 1280 tons (metric) and the motor ship, 1260 tons. The carrying capacity for the same water line is in the steamer 3080 and the motor ship 3100 tons. Excess of loading room in the case of the motor ship as compared with the steamer, 190 cbm. (6700 cu. ft.). Both ships were sent on the same trip. The steamer traveled at a speed of 8.7 knots and consumed 12 tons of coal per 24 hr. The Diesel engine vessel went with a speed of 8.66 knots and an oil consumption of 3.95 tons per 24 hr. This shows a ratio of oil consumption to coal consumption with the consumption of the auxiliary boiler used to drive the rudder engine taken into consideration, to be 1:2.88, and that shows that the ratio often in-

dicated in theoretical works of one ton of oil to four or five tons of coal is not confirmed by actual practical experience.

Table 1 shows what the situation would be if, in addition to the pure fuel consumption of both engines, we compared also the expense in lubricants, depreciation and wages. The data reported there are taken from actual experience and comparison between the Diesel engine ship Christian X, equipped with two single acting four-stroke cycle 8 cylinder engines and the steamer Uckermark equipped with a modern superheated steam plant. The increased wages on the Diesel engine ship were due not so much to the difficulty of finding proper men to manage these ships but to the constant complaints of the men with respect to the strict service which they have to maintain, the large number of repairs and installation work, as well as the excessive attention which the power plant requires from the engineer. Of particular interest in an investigation of the efficiency of Diesel engine ships is the lubricant outlay. Lubricants such as machine oil, grease and kerosene on Diesel engine ships constituted an expense of 1820 marks, while the steamer cost in this respect was only 270 marks. While steam engine plants on seagoing vessels require a lubricating oil consumption of 0.4 to 0.5 kg. per indicated h.p.-hr., in the case of the Diesel engine ships it was found that the demand for lubricants rises to 2.4, 2.5 and even more kg. per indicated h.p.-hr.

TABLE 1 MAIN COMPARATIVE DATA OF A STEAMER (S) AND DIESEL ENGINED SHIP (D) FOR A TWO MONTH TRIP

TOTAL DURATION OF TRIP TWO MONTHS; AT SEA 27.5 DAYS; IN HAVEN 28.0 DAYS; SPEED 11.4 SEA MILES

| | | Motorship (D) | Steamer (S) |
|---|---|---|---|
| (1) Fuel: | | | |
| D: sea trip, 27.5 x 11.9 | 328 tons | | |
| | 20 tons | | |
| in haven | 30 tons | | |
| auxiliary boilers | 26 tons | | |
| | 404 tons, at marks 26.56 | 10,710 | |
| S: coal, 1250 tons, at 15.80 marks per ton | | | 19,730 |
| (2) Wages: | | | |
| D: | | 3,774 | |
| S: | | | 5,070 |
| (3) Lubricants: | | | |
| D: machine oil, cylinder oil, grease, kerosene | | 1,820 | |
| S: | | | 270 |
| (4) Depreciation: | | | |
| D: 10 per cent on ship | | | |
| 12 per cent on engine equipment | | 24,680 | |
| S: 10 per cent on ship and engine | | | 18,900 |
| | | 40,984 | 43,970 |
| Operating costs per ton carrying capacity | | 2.57 | 2.74 |

On the whole, it was found that these four sources of expense, fuel, wages, lubricants and depreciation, even at low prices for oil, have shown an advantage in favor of the Diesel engine driven vessel, but an advantage which is not very striking. In this connection, however, there have been left out of consideration the cost of general maintenance and unforeseen expenses, which so far have been quite heavy for fuel engine driven ships. Apart from "child age troubles," to which all new types of engines are naturally subject, it has been found in general that Diesel engines, when in constant operation, require a far greater amount of attention on board ship than is the case with steam engines. Cases have been known where Diesel engine ships have been at work for two to two and a half years without giving any trouble, and then suddenly all sorts of disturbances, such as the ripping of cylinder cover connections, cooling water jackets, etc., started in.

A particular source of trouble is the ripping of the cylinder covers; this can be obviated, however, by proper cooling inside the cover, elimination of angles, etc. A further source of trouble is that often a brief interruption of the work of the cooling water pump or decrease in its output can cause grave troubles. The worst, however, is that such troubles are much more serious in the case of the Diesel engine ships than with steam engines because if they happen abroad in an unfrequented place, there may not be a supply of parts available and the ship is apt to be kept out of service until such parts are supplied and repairs made.

While the consumption of oil in the working cylinder of a Diesel engine is thermally more efficient than that of a steam engine, quite large amounts of heat are still lost, approximately 60 per cent. Many attempts have been made to utilize this heat on board ship; for example, by means of heating steam boilers by the exhaust gases of the engine or by heating water. The attempt to utilize exhaust heat directly for preheating the oil in the tanks involves a danger in that if the water-pipes start to leak, the water will get into the oil and this must not be allowed under any circumstances. In fact, as the oil usually has a certain percentage of water in it, it is advisable before using it in the engine, to give it an opportunity to stand still for 10 or 12 hours so that the water may separate from it. The simplest way to do this is to provide tanks of capacity approximately equal to half of a day's consumption and to have cocks at the bottom through which water might be discharged after it has been allowed to settle.

The idea of using exhaust gases from the Diesel engine under auxiliary boilers is easy to understand but does not appear as a particularly happy solution of the problem. There ought to be rather a tendency to eliminate steam boilers on engine driven ships entirely. Up to the present time most designers install steam power for such auxiliary purposes as winches, anchor hoists, rudder engines, as well as for heating. There are even Diesel engine ships upon which, in addition to the main power plant, there are, used for various auxiliary purposes, steam, compressed air, electric energy and even water under pressure, but such ships will be considered only as curiosities in the future. On the other hand, however, there have lately been built ships (like the "Fionia") on which, with a Diesel engine plant of 4,000 i.h.p., the entire auxiliary machinery and pumping plants are driven electrically, although even there, there is an auxiliary steam boiler installed exclusively to supply the fairly large demand for hot water for heating and bathing on the passenger side of the vessel.

Among the auxiliary machinery, an important part belongs to the engine starting device. The Diesel engine cannot be started on oil and on board ship it is customary to use compressed air for starting and reversing purposes, the compressors being connected directly on the crank shaft or having separate driving motors of their own. If one considers that a main engine plant of 2,000 indicated horse power requires a compressor of about 200 h.p., it becomes clear that such a compressor, with its driving engines, requires quite a lot of space and this sometimes leads to the

adoption of the otherwise less convenient direct-connected compressor.

As regards the carrying capacity of Diesel engine ships, the author states that in the first installations an effort was made to secure a high degree of reliability and the saving in weight was therefore low. Later on, however, savings in capacity were effected; thus between the steamer Santa Anna (6400 tons) and the motor ship Monte Penedo (6410 tons), the latter had the extra carrying capacity of 450 tons. It must be borne in mind, however, that this difference includes the difference between the bunker contents of coal and oil amounting to 357 tons, so that the proper decrease in weight of the motor ship with the bunkers empty, was only 58 tons. The loading space saving in the ship was also very modest and amounted to only about 1.97 per cent. (*Die Grossdieselmotorshiffe, ihre Wirtschaftlichkeit und ihre Zukunft,* Wm. Scholz, *Zeits. des. Vereines deutscher Ingenieure,* vol. 59, no. 5,, p. 86, January 30, 1915, 7 pp. *sc*).

**Railway Engineering**

### Ball Bearings on Electric Railway Cars

The article describes tests made on the use of ball-bearings in various connections on railway rolling stock and the results obtained. Its interest lies in the fact that in the test described, a wider application of ball-bearings has been made than is usually the case.

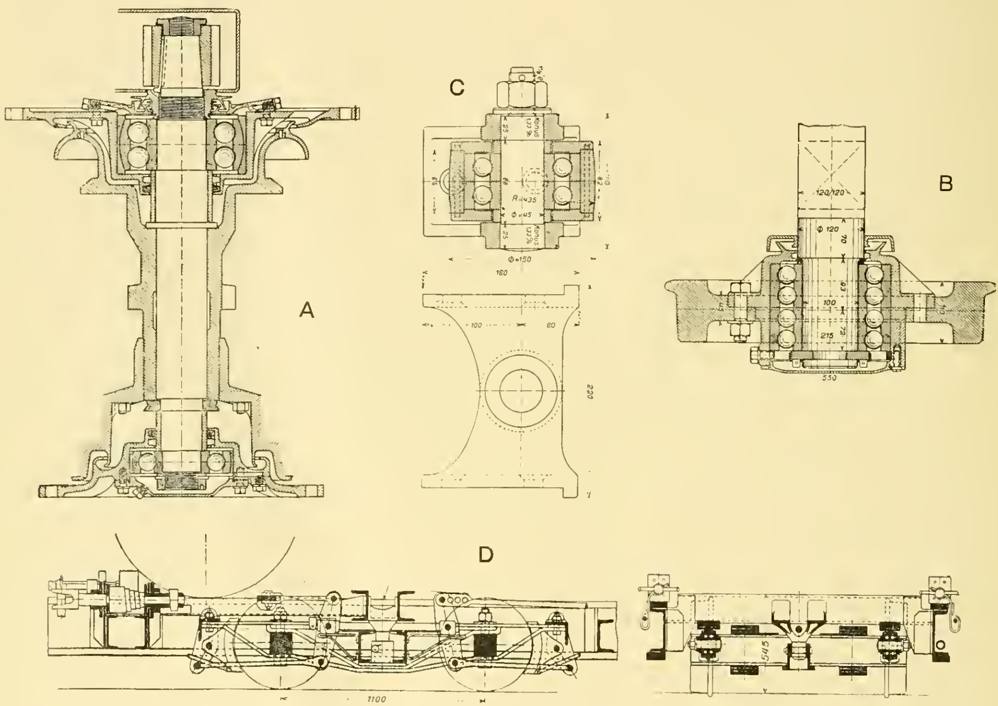



Fig. 1 Ball Bearings on Electric Railway Cars

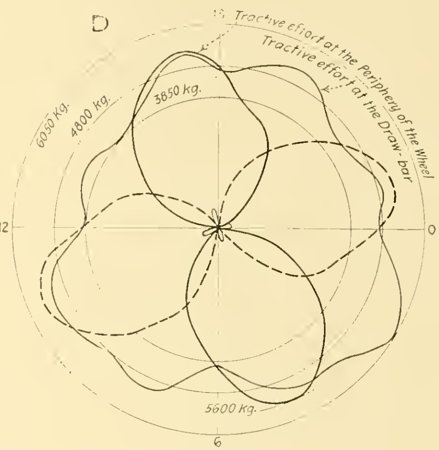
The first cars provided with ball-bearings were placed on the Montreux-Oberland Railway in 1910—two 4-axle second-class cars, with bearings made by Schmidt-Roost, of Oerliken, Switzerland. In 1911 seven more 4-axle cars, among them a diner, were equipped in a similar manner. The results were so satisfactory that the axles of all the new motor cars, passenger trailers and freight cars were equipped with ball-bearings, and at present the line has 39 cars so equipped. In new orders for rolling stock the application of ball-bearings was not limited to the axle journals, but for the first time in Switzerland, they were also introduced between the underframe and bogie of 4-axle cars. This arrangement, shown in Fig. 1A, was particularly convenient on this line with its numerous and very sharp curves which had to be handled by comparatively long cars. The results were perfectly satisfactory, smoother runs being obtained on curves of small radius.

Then a new step in the same direction was taken, and on two new motor cars, the motor shafts were also equipped with ball-bearings, and altogether eight motors were so equipped, each of them having the remarkable (for narrow-gage) average output for one hour of 114 h.p. While there never was any trouble with the ball-bearings in axle journals and between the underframe and bogie, the ball-bearing arrangement in the traction motors, where the designer was very much limited by the space available, has caused some

trouble at first, but worked perfectly later, notwithstanding the very high pressures on the bearings and the violent lateral shocks due to handling sharp curves with low-lying motors having no spring protection laterally. This is particularly so, as the motors run at 1660 r.p.m., corresponding to a maximum speed of run of 45 km. per hour, with a wheel diameter of 900 mm. (35.4 in.) and a ratio of gear transmission of 1:6.286.

Fig. B shows the way the motor armature shaft is located in its ball-bearings. Attention is here called to the spherical hollow-cut in the casing of the bearing which permits the rings holding the balls in place, a certain amount of motion, to take care of the bending of the shaft, and also an automatic adjustment without any jamming or one-sided pressure.

An interesting novelty in the application of ball-bearings were carried out in June 1914, with the registering dynamometer inserted between the bogie and the motor car. In order to be able to compare better with each other, the results obtained, without their being affected by the difference of the weight of the bogies, the total weight of the loaded trucks was the same, 26 tons, in all test runs. Nevertheless, because of continuous vibration and numerous curves following one after another, and also because the dynamometer had no device for damping, no claim to absolute precision is made here. A somewhat more reliable state of equilibrium appears to have been maintained, however, on a straight line stretch about 250 m. long and the record of the dyna-



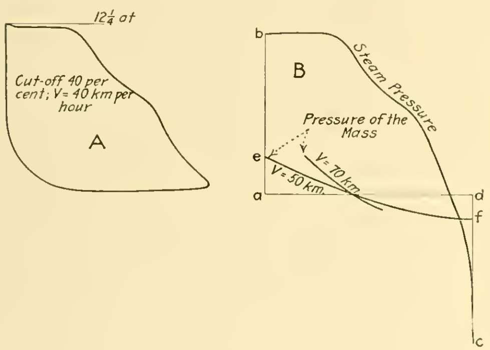
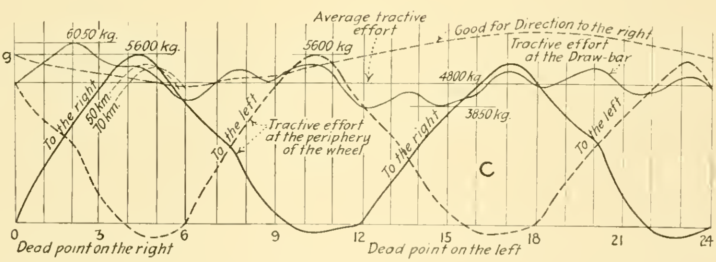





Fig. 2, A Steam Diagram; B Over-Pressure Diagram; C Linear Peripheral Force Diagram of a Twin Steam Locomotive; D Same as C, in Polar Diagram

is represented in the platform bogie shown in Fig. C. Out of the three bogies serving for the support of standard cars, weighing a maximum of 30 tons, two were equipped with sliding journals and a third with ball-bearings—Fig. C. This bogie is provided with rigid wheel axles, rigidly connected with the bogie, and the wheels loosely set on the axle and running on ball-bearings. It is said that this construction not only has the advantage of having a low internal resistance, but results in a soft and free of friction handling on curves, because the two wheels of the same axle can rotate independently one of the other.

In order to compare as precisely as possible the natural resistances of the two different types of bogies, experiments mometer showed there a natural resistance of 5.3 kg. per ton (metric) with a slide bearing and 2.3 kg. per ton with ball-bearing.

A further serious argument in favor of ball-bearings is that first they have to be lubricated approximately once in six months as compared with 10 to 15 days in the case of a motor or passenger trailer car equipped with slide bearings, and further, that the life of the ball-bearing is from 10 to 15 years as against the life of a slide bearing of about two years. (*Erfahrungen mit Kugellagern im Betriebe der Montreux-Berner-Oberland-Bahn*, R. Zehnder-Spoerry, *Schweizerische Bauzeitung*, vol. 65, no. 5, p. 49, January 30, 1915, 4 pp., 4 figs. *de*).

UTILIZATION OF ADHESION WEIGHT IN STEAM LOCOMOTIVES.

The article discusses the utilization of adhesion weight in the case of steam locomotives, and the proper design of locomotives.

The author claims it to be inadmissible to use as a measure for the determination of the adhesion, the sum of rotating forces on the right and left drivers. He states that it is not safe to rely on what is known as "starting diagrams." There is no such thing as a starting diagram proper. If a locomotive were to start twenty times, the first set of indicator diagrams would come out different in every case in accordance with the crank position at starting, position of the throttle, the experience of the engineer, etc. The diagrams which the author uses, are not starting diagrams proper, but have been taken at average speeds, say 20 km. per hr., that is, during the period of acceleration of the train, and even such diagrams are not fully sufficient for the determination of the utilization of adhesive weight.

He discusses further the interesting question of the behavior of a steam locomotive as compared with that of an electric locomotive during the period of acceleration. In Fig. 2A is given a steam diagram for a cut-off at 40 per cent. Although it has been taken at 40 km. per hr., the throttle losses are so slight that it might be good for 10 to 20 km. per hr. just as well. At the low velocities of 10 to 20 km per hr., the action of the pressure of masses on the crank pin can be neglected and the forces acting, in the direction of the axis of the cylinder, on the driving pin at various positions of the crank can be obtained from the ordinates of the over-pressure diagram *abcd* in Fig. 2, from which, in the usual manner, the diagram of the peripheral forces can be drawn, with proper consideration of the finite length of the driving rods. Such diagrams are shown in Figs. C and D. In Fig. C, the pulls acting on the right and left wheel rims are plotted as ordinates over the developed wheel circumference.

Owing to the elasticity of the axes, it is not permissible for the purpose of determining the value of friction of wheel against the rail itself, to add together the values of forces acting on the right and left wheels and then count them as the adhesion draft referred to the axes or an ideal wheel. As a matter of fact, the value of friction draft does not have to be considered at all as far as the utilization of adhesion weight on a wheel is concerned. In Figs. C and D it is plotted as a thin wavy line with a maximum value of 6050 and a minimum value of 3850 kg. At the same time, the maximum value of the tractive effort never coincides with the maximum value of utilization of adhesion weight on the wheels since the maximum peripheral force on the driving axis is distributed fairly uniformly over the right and left wheel groups, (it varies from 6050 kg. to 3250 or 2800 kg.). The average value of the tractive effort, as shown in Figs. C and D, can be taken at 4800 kg. and it has the same average value in the electric locomotive with rod drive used for comparison with the steam locomotive. If in the electric locomotive direct current is used, then the tractive effort is of constant value throughout. With polyphase current, because of the overlapping of phases, it is nearly constant, while with single phase it varies quite considerably. In the first two cases, the average tractive effort of 4800 kg. represents also the maximum value acting on a single wheel at the instant when the crank of the counter driving wheel is at its dead point, the minimum value being zero. It appears from Figs. C and D, therefore, that a two-cylinder steam locomotive with outside cylinders, as compared with an electric locomotive of the same average tractive effort, develops a peripheral pressure on the wheel, in so far as it affects the utilization of adhesion weight, 16.5 per cent greater and this result is good even when the conditions assumed do not favor the steam locomotive, viz., cut-off of 40 per cent and only a 6.3-fold length of driving rods. Several circumstances may, however, materially improve the condition of work in steam locomotives.

In the above example it was assumed that the locomotive had outside cylinders, and that the moments of torsion originated on one side of the machine in the driving and coupling pins, were transmitted directly through the spokes of the wheel on to the "friction coupling" between wheel and rail. But when there are inner cylinders and cranked axles, then the moments of torsion of one side of the machine will be transmitted not exclusively on to the wheels on one side, but, in accordance with the torsion of the axis, will be distributed in a non-uniform manner over both the right and left sets of wheels. As a result, the maximum stress which falls on one wheel, will be reduced. A limit in this respect is set by a locomotive with a Klien-Lindner driving axle, in which the tractive effort is transmitted exactly along the center of the axis on to the hollow wheel. In this case, the maximum tangential force on the circumference of the wheel is only about half as large as in an electric locomotive with rod drive and equal tractive effort. As far as the utilization of adhesion weight is concerned, the Klien-Lindner locomotive and the locomotives with two inner cylinders, and with three or four cylinders lying side by side, are all of them superior to electric locomotives, because tractive efforts which have to be transmitted by a single coupled set of wheels, do not reach quite as high maximum values.

The locomotive is, however, stressed up to the limit of friction not only during the acceleration of the train, but also at comparatively low velocities, especially when pulling upgrade. For how long and how often adhesion force should be used in driving at higher speeds is purely a question of boiler and grate utilization. Locomotives used on uneven grades have to be prepared to stand particularly high stresses in this regard. At high speeds, the action of pressure of the masses on the driving pins (the magnitude of which is indicated by the ordinates of the area, *adfe*, Fig. B) must not be neglected. The ordinates of the diagram *ebcf* show the piston pressures acting on the driving pin when the speed is 50 km per hr. and Fig. B permits one to estimate the piston pressures also at speeds up to 70 km. The action of the pressures of masses is of an equalizing nature; that means that because of it the piston pressures become more and more uniform, and the same applies to the tractive efforts acting on the periphery of the wheel, as indicated in Fig. C by the dotted curves between the ordinates 3 and 6. Since the pressures of masses do not affect the average tractive effort of 4800 kg, the excess of peripherel force action on the wheel in steam locomotives is less than the maximum of 4800 kg. of electric locomotives. Strictly speaking, the steam diagram of Fig. A is not precisely correct for velocities of 50 and 70 km., since greater throttling losses appear at higher velocities. The latter, how-

ever, are so dependent upon the dimensioning of the organs of steam distribution that in this connection it cannot be considered as of material importance.

One more point has to be mentioned, and this is that under certain conditions, the steam locomotive is at a disadvantage as compared with the electric locomotives, in as far as the utilization of adhesion weight is concerned, and this disadvantage lies in the fact that the centrifugal forces of the balancing masses of the counterweights oppose the action of the adhesion weight. In the two-cylinder locomotive, however, with the driving gear running in counter-directions and in the four-cylinder locomotive of the Borries type, the equalization by counterweights is omitted and therefore the utilization of adhesion weight is not affected at all.

The author comes to the general conclusion that in steam locomotives there are considerable variations in the utilization of adhesion weight not dependent upon the construction proper. Theoretically, however, it may be assumed that the steam locomotive utilizes the adhesion weight just as well and perhaps better than the electric locomotive and that the parts of a steam locomotive serving for the transmission of power are more favorably stressed than the mechanical parts of the single-axle polyphase-current electric locomotive.

*Die Ausnutzung des Reibungsgewichtes bei der Dampflokomotive*, Dr.-Ing. Ludwig Schneider, *Dinglers polytechnisches Journal*, vol. 329, no. 50/51, p. 696, December 19, 1914, 5 pp., 4 figs., *t*).

**Steam Engineering**

GAS EXPLOSIONS IN LIGNITE FIRED BOILER PLANTS.

The article discusses explosions of gas in lignite fired boiler plants and methods of their prevention.

In German practice, several accidents are recorded of gas explosions in the flues of steam boiler plants. Such a case, for example, occurred in a rolling mill boiler equipped with a step grate. In that case, a lignite, rich in gas, was used and the fireman was in the habit of piling large masses of fuel over the bed. Once, shortly after he had loaded up the grate in that manner, there was a tremendous explosion which did a lot of damage to the plant.

Another case of considerable interest occurred, also in a German plant, where a new boiler had been installed and was being heated up. At first a wood fire was lighted on the grate of a Ten-Brink furnace. Over this wood fire the fireman piled up a heap of dry Bohemian nut lignite, high enough to reach the tip of the funnel of the hopper, the damper being wide open. As soon as the coal was piled up in this manner, it was noticed that the draft fell off and smoke began to come out of the grate. This was followed suddenly by a tremendous explosion which did a large amount of damage and, among other things, destroyed the boiler setting.

After things had been put back in shape, another attempt to fire up the plant was made, and the next day there was a second gas explosion which did, however, somewhat less damage than the first. As the concern which contracted for the installation of the boilers was under the impression that these accidents were due to lack of sufficient draft, they have replaced the old smoke stack (22 m. high and 0.5 m. wide), with a new smoke stack 35 m. high and 0.75 m. in diameter), even though with the old smoke stack there was a draft of more than 11 mm. of water. The hoped-for results, however, failed to materialize, as several days after operations were resumed, there occurred a third explosion more violent than any of the preceding ones, which indicated that the cause should be looked for elsewhere than in the conditions of the draft.

Further observations have finally shown that the inclination of the grate of approximately 48 deg. was too steep for the kind of lignite used. Accordingly, the fuel used to slide down without being consumed and in this way covered up the fire so that what occurred was to a large extent similar to the case of the fireman in the first explosion, who heaped too much fuel on the fire. A new grate was put in with an angle corresponding to the angle of repose of the lignite and no more trouble was experienced.

The German associations for boiler inspection have collected quite a large amount of material on this subject and the fundamental rule which they developed is *to look out that the boiler furnace should not become practically a gas producer.* The firing arrangements should be adapted to the kind of fuel used and the fireman should be particularly cautioned to maintain the entire bed uniformly covered with fuel to a height that will permit the flame to break easily through. If this is done, all the gases developed can rapidly pass out and be burned above. The thickness of the bed depends upon the kind of fuel used. If it is in large lumps so that both the flame and gases can easily pass through it, and of a nature of coke, the bed may be thicker than with fine material rich in gas.

The article goes on to point out measures similar to the above. Among other things, the author recommends opening the fire door, ash door and smoke stack damper from time to time and to admit as much air as possible into the flues, so as to remove any dangerous gas mixtures, or at least to lower their temperature and change their combination. Where the boiler has dead corners in which hot gases may accumulate without being subject to the action of the smoke stack draft, proper openings should be provided to drive such gases into the smoke stack. It is also a good idea to place in various parts of the flues, safety valves opening outward so that, if a gas explosion should occur, its action would be less destructive to the general system. (*Verhütung von Explosionen bei Braunkohlenverfeuerung in Kesselanlagen*, P. M. Grempe, *Braunkohle*, vol. 13, no. 46, p. 614, February 12, 1915, 3 pp. *p*).

EXPLOSION OF A LOCOMOBILE BOILER

The boiler shown in Fig. 3A which exploded in October 1913 in Gehersberg (Upper Bavaria, Germany) was made in Germany in 1873 and licensed for a working pressure of 5 atmospheres absolute. Its heating surface was 7.2 qm. (77.4 sq. ft.), the area of the horizontal grate built-in in the fire box, 1.43 qm. (15.38 sq. ft.), a total volume of 108 cbm. (3814 sq. ft.), with a steam space only 150 mm. (5.90 in.) high. The sheets of the boiler were connected with each other by simple lap riveting The locomobile was used for farm purposes.

On the day of the explosion, it was to be used for driving a threshing machine and was being heated up after a stop of 14 days. The heating was started at half past five in the morning and at half past six the boiler showed a pressure of 2 atmospheres. The attendant considered this pressure too low and started to heat it faster; soon after, the

boiler exploded with a tremendous noise, throwing large parts at a considerable distance. The water gage was not broken but much damage to property was caused and two men were injured.

The boiler was subjected to an internal inspection in April and while inward bulging was observed in the crown sheet, it did not appear to be of particular depth. It was again inspected, externally, in the fall and no dangerous developments were found. As to the causes of the explosion, it is rather difficult to form a precise opinion because the parts were not inspected until five days after the explosion when the pieces of the boiler were thoroughly covered with dirt and rust. Since, however, it was found that the crown sheet remained in practically the same state as when it was inspected before and a certain amount of scale was still sticking to the fire box walls and fire tubes, it seemed to be clear that the explosion was not caused by lack of water.

The state of the plates was such as to make it impossible to determine whether the explosion was due to previous cracks. It might be possible that it was due to excessive pressure although the attendant states that immediately before the explosion the pressure indicated was only 2 atmospheres. This may be true but it appears rather unusual that after a heating of only one hour in the early morning, there should be a pressure of 2 atmospheres after the boiler has been kept cold for a long time and especially in view of the fact that the water must have been quite cold (4 to 5 deg. cent. — 39.2 to 45 deg. fahr.). The attendant, further, tested the water gage before starting the boiler and found that the water flowed through all of the cocks. One may conclude from this that, by way of precaution, he overfilled the boiler with water and if such was the case, it might be possible that the water, because of its expansion when heated, filled up almost entirely the very small space remaining in the boiler, so that when the steam began to form, the pressure on the boiler walls began to increase very rapidly. When the manometer showed 2 atmospheres, this pressure appeared too small to the boiler attendant for starting the engine; he continued to heat it and a few minutes later the boiler exploded. These few minutes may have been quite sufficient to raise the pressure to such a height as to cause at somewhat weaker places a rupture of the boiler walls and as soon as this happened, the superheated boiler water suddenly expanded into steam and thereby produced the explosion. It is believed, therefore, that in the final account, the explosion was due to excessive filling with water. It is possible old cracks, not previously noticed, may have contributed to the weakening of the shell. (*Explosion eines Lokomobil-Dampfkessels,* Müller, *Zeits. des Bayerischen Revisions-Vereins,* vol. 18, no. 23, December 15, 1914, p. 211, 2 pp., 5 figs. *dp*).

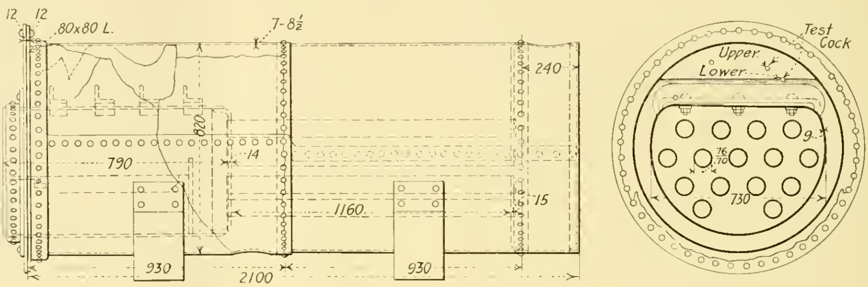



FIG. 3 LOCOMOBILE BOILER WHICH EXPLODED

### COMMUNICATIONS FROM THE CHEMICAL LABORATORY OF THE BAVARIAN ASSOCIATION FOR BOILER INSPECTION

Feed water with high soda or mud content tends to form wet steam especially in heavily loaded boilers. In such cases, and particularly where the feeding of the boiler is intense, some of the boiler contents, that is, water and mud, are easily carried away with the steam. Mud is particularly easily carried over into the steam piping if the feed water contains oil. In that case, the oil drops either settle on the deposited particles of mud or, where the oil contains saponified particles, it helps to form foam. The mixture of boiler mud with oil has a very low specific weight, and floats on the surface of the water, while if it were free from oil, it would settle in the boiler at the spot where the movement of the water is least.

In a steam plant, considerable amounts of mud have been carried over by superheated steam into the pipes and heating elements and there have caused considerable trouble, which required tedious cleaning. In addition to fresh water feed water containing oil was also used. The analysis of the whitish deposit in the pipes and radiator elements, made in the chemical laboratory of the Association, showed the presence of considerable amounts of calcium dioxide but only 1.7 per cent of oil. When dried, this mud was very light and voluminous, 100 g. occupying a space of about 450 ccm.

In another case, in a superheater steam boiler of a locomobile, purified feed water was carried over into the superheater because of the large content of soda and the intensive feeding, and in the superheater was converted into steam. The salts in the water in the form of fine dust, reached the steam chamber of the engine and there, together with the cylinder oil, formed a black-grey crust 2 to 3 cm. (0.78 to 1.18 in.) thick. At first oil was blamed for this crust formation, but laboratory investigation proved beyond doubt that it was due to the action of the boiler. A quantitative analysis of an average sample of the crust gave the following results (in per cent):

| | |
|---|---|
| Sodium carbonate........................ | 48.0 per cent |
| Sodium sulphate........................ | 26.5 per cent |

| | | |
|---|---|---|
| Sodium chloride | 6.7 | per cent |
| Original material soluble in toluol | 3.0 | per cent |
| Material soluble in toluol in the mass obtained by decomposition with hydrochloric acid of the residue after the first extraction with toluol | 1.1 | per cent |
| Carbon from decomposed cylinder oil | 7.5 | per cent |
| Calcium carbonate | 0.7 | per cent |
| Silicic acid | 0.16 | per cent |
| Iron oxide | 0.13 | per cent |
| Moisture and traces of magnesium as residue | 6.21 | per cent |

This shows that the crust formed in the steam chamber of the locomobile consisted to the extent of nearly 81 per cent of easily soluble salts which are always present in superheated feed water made from purified water, viz., soda, sodium sulphate and common salt. The carbon comes from the cylinder oil decomposed by continued action of superheated steam. The parts soluble in toluol are partly non-decomposed lubricating oil and partly asphaltum materials either initially present in the oil or formed in it through the processes of pitch formation. (*Mitteilungen aus dem Chemischen Laboratorium des Vereins, Zeits. des Bayerischen Revisions-Vereins*, vol. 18, no. 23, p. 213, December 14, 1914, serial article, not finished. *e*).

### German Progress in Steam Boiler Firing.

A continuation of the article describing new types of grates and steam boiler firing systems abstracted in *The Journal*, March 1915, p. 185.

C. Fischer of Frankfort-on-Main uses a pair of roller levers for driving the fuel-throwing shovel of his stoker, (German patent No. 279,078). During the rolling, motion initiated by the driving lever is transferred to the driven lever in such a manner that the latter moves with a greater amount of force but at a lower velocity, on account of which, although the force of the motion decreases, the motion itself is accelerated all the time. Fig. 4A gives a diagrammatic side view of one of the designs of this drive. The device for moving the shaft *a* of the fuel-throwing shovel consists of two roller levers *b* and *c*, of which the first is the driving one resting on the shaft *d* while the other one is a driven lever and moves the shaft *a*. In the frame *e*, there is provided a bell crank *f* which is moved by the crank disc *h*, through the rod *g*. The bell crank *f* acts directly on the driving roller *b*. In order with such an arrangement to secure a certain amount of adjustability, pedal *i* of the bell crank is made adjustable by means of a hand wheel. In order further to secure continuously variable drive of the lever *b* and through that, of the fuel-throwing shovel, the lever is located on an eccentric *k*, rotatable by means of a locking device *l* and *m*. The motion of the wheel regulating the admission of the fuel to the fuel-throwing shovel, resting on the shaft *n*, can be varied in a similar manner by locating the locking device *o.p.* on the shaft *n* and by connecting it, by an intermediary lever *q*, or the crank disc *h*. The driving lever *b* can also be designed as a laminated plate spring so as to secure a certain amount of elasticity.

A peculiar stoking device has been obtained by J. Hierold of Erfurt (German patent No. 279,469). The fuel is delivered to a rigid plane grate from a hopper located so as to secure a predetermined height of fall, and is moved forward by a circular brush engaging into the grate openings. Fig. B gives a vertical longitudinal section through this stoker as built-in in a fire tube boiler. The grate is here supported by a rigid frame *f* in such a manner that the circular brush *a* moves on the upper part of the grate from the front to the rear end, and on the lower side from the rear end towards the front end, without striking any part of the grate. To make the disc *a* move, there is located on both sides of the grate frame a chain drive protected from the action of the fire. The chain drive and the fire plate *b* extend somewhat forward of the boiler front wall. On that part is delivered the fuel from the hopper *c*, through a height of fall regulated by the valve *d*. The baffle plate *g* serves to limit the extension of the fire and to protect the hopper.

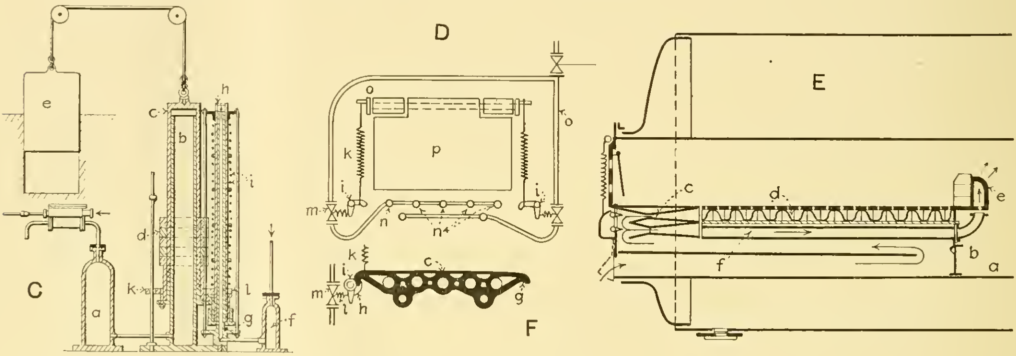
In draft regulators which regulate the draft in accordance with the steam pressure, it is a usual practice to employ water under pressure for actuating the regulator valve. In such a case, the steam pressure acts on a membrane through a column of water of condensation which accumulates over that membrane, and the latter, in its turn, actuates the valve in the piping containing water under pressure. There is, however, a difficulty in such an arrangement due to the fact that the column of water of condensation, owing to its friction against the walls of the piping, opposes the impulses which have to be transmitted to the membrane, this resistance being proportional to the steam pressure exercised on the column of water. As a result of that, the membrane begins to move only when the variation in the boiler pressure is greater than the frictional resistance of the water column in the piping which contains the water of condensation.

The Apparatebau- und Herdkessel- Industrie Karl Alt & Paul Jerome in Strassburg i. E., Germany, has patented (German patent No. 277,331) a draft regulator which is claimed to be immune from this source of trouble. Inserted in the piping between the membrane and the boiler, there is a device which reduces the boiler steam pressure before it begins to exert a pressure on the water column acting on the membrane, and this reduction occurs in such a manner that to certain pressure variations in the boiler, there correspond greater pressure differences on either the water column or the membrane; further, shocks uninterruptedly following one after another produce a certain restlessness in the membrane, which renders harmless its inertia with respect to motion. By means of these two separate actions, a high sensitiveness of the membrane is secured and it is made to respond to pressure variation of $^1/_{20}$ of one atmosphere. As a result, should the pressure rise by $^1/_{20}$ of an atmosphere over the working pressure, the slide damper is immediately closed and when the pressure falls by $^1/_{20}$ of an atmosphere the slide damper is opened.

In order to ensure that, where steam pressure draft regulators are used, the opening of the fire box door should bring about the closing of the slide damper, J. Matter has designed the device shown in Fig. C, (German patent No. 276,859). The slide damper *e* is suspended from the hydraulic piston *c*, loaded with the weight *d*, the piston moving in the hydraulic cylinder *b* connected with the pressure tank *a*. The admission of water to tank *a* and cylinder *b* occurs through the valve gear operated by a rod dependent upon the opening and closing of the fire box door. Beside the cylinder *b*, there is provided also a steam cylinder *g*, supplied with steam under boiler pressure by which the piston *h* is raised by the steam pressure against the pressure of the spring *i*, surrounding that piston. The piston *h* carries in its lower part a strongly built flange *l*, which overlaps the flange *k* on piston *c*. Since

both pistons are guided vertically in their guide rods, the piston $b$ is carried away by the piston $h$ and therefore the slide damper is adjusted in accordance with the steam pressure in the boiler. When the fire box door is opened, the piston $b$ rises high enough to have the slide damper $e$ entirely closed and after the closing of the fire door, comes back again to a position, the height of which is determined by the location of the flange $l$ or piston $h$ and which corresponds exactly to the steam pressure prevailing in the boiler.

Ch. Hülsmeyer has devised a method of regulating the process of combustion by the weight of the fuel on the grate (German patent No. 277,332). One design of this rather complicated arrangement is shown in Figs. D, E, and F. The grate $a$ is made freely oscillating about the point $b$ and consists of a tuyere plate $c$, grate bars $d$, fire bridge $e$ and supplementary air piping $f$. The fire bridge $e$ is connected by bolts or angle irons with $c$, in which are located the removable grate bars $d$. The end of the grate consisting of the bed $c$ is made freely oscillating and rests on the shaft $i$ which is kept in its position by the springs $k$ and is balanced by the weight of the freely oscillating part of the grate. The shaft $i$ is provided with a cam $l$, which in a normal state of operation keeps the valve $m$ closed. When the grate is loaded with fuel, the tip $g$ of the tuyere plate $c$ presses so hard on the cam $h$ that the cam $l$ opens the valve $m$ and admits steam through the piping $o$ to the nozzles $n$, $n^1$, etc. The amount of steam admission varies with the course of combustion and the load on the grate. The springs $k$ are located on eccentric cams on the fire door $p$ so that when the latter is opened, an additional tension of the springs is obtained which results in the valve $m$, i.e., the steam admission to the grate, being closed. The rate of air transmission through the layer of fuel varies as the load on the grate; and the former may be utilized in order to obtain a still closer regulation by inserting in the separate air chambers a measuring pipe with several openings. This pipe may be filled with a liquid the level of which would vary as the draft, that is, as the resistance of the fuel bed. If this device for measuring the draft be filled with mercury and suitable electric contacts be placed in the glass walls, it would be possible to regulate automatically the air admission to the various sections of the grate (*Neue Patente auf dem Gebiet der Dampfkesselfeuerung*, Pradel, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 38, no. 6, p. 45, February 5, 1915, 2 pp., 7 figs. *d*).



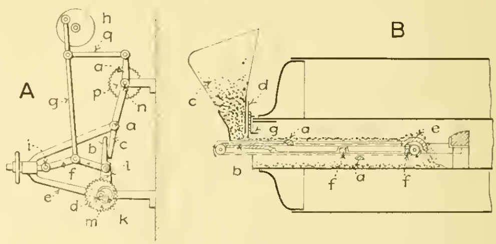




Fig. 4 New Devices in Boiler Firing

# ENGINEERING SOCIETIES

## ENGINEERS' SOCIETY OF PENNSYLVANIA

*Journal, vol. 6, no. 12, December 1914, Harrisburg, Pa.*

Service and Tests of Mayari Incline Cables, James E. Little

The paper describes tests of inclined cables on an iron mine property in Cuba.

The Mayari mines in Cuba operate a rather unusual inclined cable railroad over which 50 ton capacity steel cars can be lowered in trains of three through a total vertical height of 1084 ft., the maximum grade being 25 per cent. These conditions of operation require a cable having a working strength of about 150,000 lb. The inclines are only for the purpose of lowering loads and the conditions are therefore quite different from those met with on a hoisting incline. The machinery includes a double 30 in. x 30 in. steam engine but the power is employed merely to start the cars moving, though occasionally it is necessary to use steam over points where loads do not sufficiently overbalance the empty side.

The article describes in some detail the arrangement of the cables. A cable is carried along the track on cast manganese steel rollers with rolled manganese steel axles cast in, the axles running in rough cast iron half bearings. After three years' service, the original manganese steel rollers show no apparent wear. The tensile strength per sq. in. metallic area in cable section has been found to be from 175,000 to 182,000 lb. while the actual tensile strength of the wires vary from 728,000 lb. to 751,000 lb.

The article describes fully the tests made on the cables.

The object of the tests was to ascertain the relative strength of the different cables when new, as well as the strength of used specimens, this information to serve as a guide in the operation of the incline. Tests of three cables delivered between December 1912 and October 1914 have shown that the last cable is about 3.5 per cent stronger than the average of its two predecessors.

To soften the cable in order to be able to cut it in Cuba, where the facilities for doing such work were naturally limited, it was annealed by a wood fire, at a point to be cut. When the socket was being placed on the specimen, this annealed end was not noticed and was not sheared off. Consequently, when tested, it broke at the annealed point 8 in. from the socket under the comparatively low tension of 216,-200 lb., while the remaining part of the specimen showed a breaking strength of 451,900 lb. All broken wires at the annealed point showed an unusually high elongation and reduction. In other tests, it was noticed that new cable specimens break with very little warning, each part of the cable taking its proper proportion of the load; the breaking strength was, however, about 80 per cent of the total wire strength, which has proved that the cable was very carefully manufactured.

The article also contains detailed data of tests on the different wires used in cables. Illustrations are given reproducing the photomicrographs showing the condition of the worn surface of the cable wires magnified 50 diameters. It appears that in the manufacture of a cable for such a use, the great problem is the selection and treatment of material so as to reduce the hardening effect on the surface of the wire due to abrasive friction, to a minimum, without unduly sacrificing the tensile strength or flexibility of the cable (14 pp., 5 figs. *e*).

### ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

*Vol. 30, no. 8, November 1914, Pittsburgh*

Construction Details of the Panama Canal Lock Gates, R. A. Pendergrass
Recent Developments in the Heat Treatment of Railway Gearing, W. H. Phillips (abstracted)
Steam Turbine Mill Drive, J. D. Berg (abstracted)
Discussion on Tests of Large Reversing Engine and Rolling Mill (for abstract of original paper see *The Journal*, January 1915, p. 55)

Recent Developments in the Heat Treatment of Railway Gearing, W. H. Phillips.

The paper discussess the manufacture of railway gearing, partly historically and partly by describing a new method of heat treatment called the B. P. Process.

The development of the railway motor gear in its various stages, (cast iron gear, malleable cast iron, cast steel four-spoke, cast steel six-spoke, forged steel, rolled, hammered and rolled, flexible gear) and the pinion is briefly described. After this, the author proceeds to a discussion of the method of heat treatment and its varions processes. The most interesting part is that referring to the B. P. Process which is a secret process, the details of which the author does not state. From the information given, the B. P. Process consists of the following sequence of operations: annealing, machining, quenching and drawing. A careful selection of the raw material and the quenching operation constitute the main feature of the high quality of the product. It is claimed to produce a very hard material, of high tensile strength without losing its ductility. The hardness tapers off gradually from the wearing surface to the center of the tooth.

In the discussion which followed, W. L. Allen stated that the B. P. Process was the outcome of years of research on the part of the Nuttall Company, which aimed to produce gearing having high surface hardness combined with great strength, and to obtain the refinement of structure at less cost than is possible through case hardening. The B. P. Process does not develop as efficient a gear as is brought about through case hardening, but the efficiency which is produced in this process very closely approaches that of the case hardened material and at so much less cost as to make the B. P. grade of gearing very much more economical for the average present day normal operative service.

The same gentleman stated that the Nuttall Company has made a great many experiments to determine the relative merits of pinions cut off forged and rolled bars as compared with pinions made from individually forged or pressed blanks and has found that in some cases the individually forged blanks produce a stronger and better pinion than those made from blanks machined from bars. He stated,

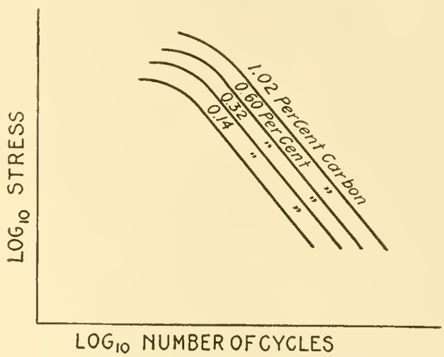



Fig. 5 Diagram Showing the Life of Carbon Steel in Repeated Bending at Various Stresses

however, that it is his opinion that in pressed forging, the material is compressed at the center more than either in hammering or in rolling and the result is that a more homogeneous mass throughout is produced than in the hammered, forged or hot rolled processes. He stated also that some experimenting is being carried on with chrome-vanadium steel for gearing as well as manganese-vanadium steel entirely free from chrome and with the manganese content of about 1¼ to 1½ per cent. No definite data have been obtained.

J. S. Unger said that a process was brought out several years ago to harden the teeth of cast steel gearing by coating the inside of the mould with powdered ferro-manganese. When cast, the temperature of the molten steel was high enough to form an alloy on the surface giving what might be called manganese steel which did not work very rapidly. Another process was brought out in which ferro-chromium was substituted for ferro-manganese. These teeth were very rough and sometimes full of holes and sometimes so hard that it was impossible to machine them. When a gear of this kind was put in service where sudden reversal or heavy starting loads were common, the hard alloyed surface would

sometimes shell off, causing trouble. At one time, experiments were made with the ferro-manganese gear in contact with two ordinary cast steel gears and the manganese gear outlasted the others three to one. While it showed very little wear, it wore out the special gears two or three times as fast as they would have worn out had the three gears in contact been of a softer material, so that the wear was simply transferred from one gear to the other.

W. R. Wigley made a series of tests on the resistance of steel to fatigue and the effect of heat treatment upon that resistance. Four grades of carbon steel were used in making the tests with carbon content of 0.014, 0.032, 0.061 and 1.02 per cent. The pieces were tested by bending them back and forth, thus starting up transverse stresses in the material. For each piece, the bending stress was computed and the number of cycles of bending back and forth counted. By changing the motion of bending in the various pieces of a series, it was possible to determine the life of the material at various stresses. When plotting the results (Fig. 5) a special plot was used; the ordinates were $\log_{10}$ of the stress and the abscissae were $\log_{10}$ of the number of cycles. From these curves, it is evident that at any stress, the higher carbon steels withstood the repeated stresses better than the lower carbon steel. In these tests, however, the loads were applied without impact, and impact might change the relation to some extent. One of the things upset by these experiments, in the speaker's opinion, was the belief in a natural elastic limit. The tests seemed to indicate that there is no such thing as a natural elastic limit at stresses below which a steel will have infinite life against repetitions of load.

### Steam Turbine Mill Drive, J. D. Berg

The article describes a low pressure steam turbine installation for driving two stands of 18 in. three-high mills of the Carpenter Steel Company at Reading, Pa.

This installation is to a certain extent similar to that installed about four years ago at the Calderbank Steel Works of James Dunlop & Company (near Glasgow, Scotland), where a low pressure steam turbine drives a three-high 28 in. plate mill. The Carpenter Steel Company formerly drove their three-high roughing mills by means of a 36 in. x 36 in. simple engine at speeds of from 70 to 100 r.p.m. This engine operated condensing, but its economy was very poor. A little over a year ago a very careful study was made to better the general economy of operation and several methods were considered. The installation of a new compound engine for driving the roughing mills and a modern central condensing system were rejected because, on account of the wide fluctuations of load on the engine and the fact that the normal horse-power required was comparatively small, the first cost and economy of this type of installation were not attractive.

A low pressure turbine generator with condenser and motor drive for the mill would have worked out better had there been a greater demand for power for other purposes in the plant, but as the major part of the power would have

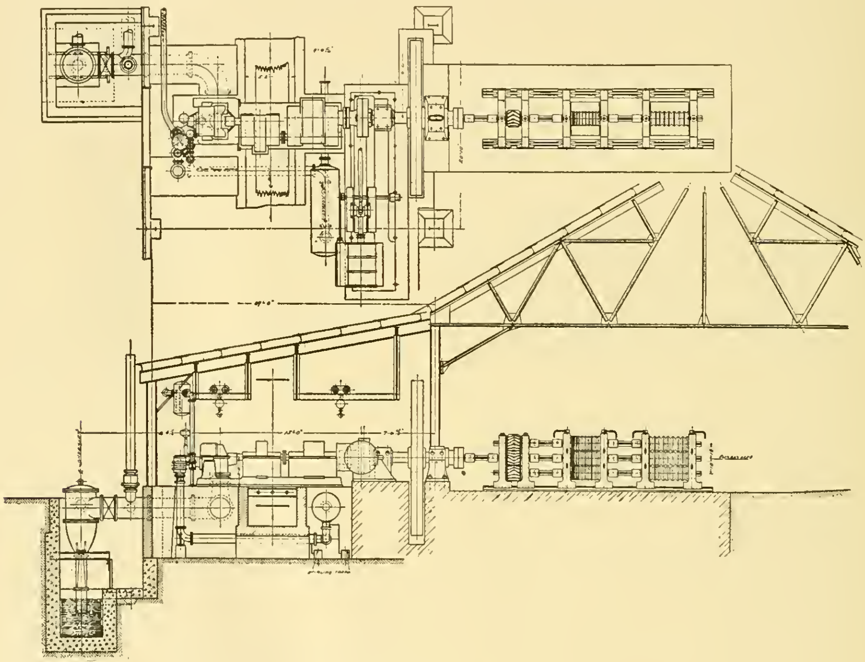


Fig. 6 Steam Turbine Rolling Mill Installation

been used on the roughing mill, several disadvantages to this scheme were found, such as the high original cost of installation and a loss of from 15 to 20 per cent of the available energy in the steam through electrical generation and transmission. As a result of this consideration, it was finally decided to install a low pressure turbine with a double reduction gear connected to the roughing mill, and to obtain the steam supply for the turbine by running the finishing mill engine non-condensing.

The article describes in detail this new installation of which Fig. 6 shows the general layout. Very careful attention was given to the question of supplying dry steam to the turbine. In the 8 in. supply line, a special low pressure receiver-separator was installed, and between the separator and the turbine throttle there was a length of about 12 ft. of straight piping. In this 12 ft. of piping, made with a 10 in. inside diameter, a coil of 1 in. copper pipe was placed, to which a live steam connection was made at one end and the other end led to a steam trap

Immediately before the low pressure throttle valve of the turbine, a Cochrane multiport flow valve was placed, the purpose of which was to prevent the loss of vacuum in case of failure of the pressure or failure of the exhaust steam supply. The following velocities were used in deciding upon the various pipe sizes: On the low pressure steam supply to the main turbine, 9500 ft. per minute; on the exhaust from the main turbine, 26,000 ft. per minute for the maximum condition and 16,700 ft. per minute for the normal condition; on the water line supplying the condenser 4.6 ft. per second on the discharge line and 3.5 ft. per second on the suction line. The exhaust line from the turbine driving the circulating pipe was figured for a future maximum velocity of 25,700 ft. per minute, and for the present condition, 15,500 ft. per minute.

The turbine is of the combination high and low pressure type and is designed to carry a normal full load of 350 h.p. with 120 lb. steam pressure at the turbine throttle and 3 in. absolute pressure in the turbine wheel case. In order to take care of overloads, the turbine is designed to operate with mixed pressure and, with steam at 3 lb. gage on the low pressure side and 120 lb. on the high pressure side, will carry 600 b.h.p. continuously. It is also designed to carry the full overload of 600 h.p. on high pressure steam only.

The turbine is of the De Laval multistage impulse type containing nine wheels with one row of buckets on each wheel. The turbine shaft operates at a speed of 5000 r.p.m. It is geared to 600 r.p.m. and this shaft in turn is geared to 100 r.p.m., the gears being of the double helical involute type with 45 deg. teeth. The pinion teeth in each case are cut from chrome nickel steel forged bands, the gears being made up of cast iron centers on which are shrunk rolled steel bands. The 600 r.p.m. shaft is supplied with a tachometer having a 4 in. circle with speed indications from 200 to 800 r.p.m. in 300 deg. of the circle. The entire cost of the installation consisting of the turbine, reduction gear, condenser piping, circulating pump, etc., delivered and erected, approximated $25,000. On account of the better economy of the turbine, it has been possible to operate the plant on about 300 boiler h.p. less than before and to effect the saving of approximately $15,000 per year in operation.

This turbine and the turbine at the Calderbank Steel Works in Scotland are the only two installations of their kind in existence.

In the discussion which followed, Jos. Breslove gave some data concerning the Calderbank Steel Works plant and especially the reduction gear used there. The reduction is effected through two gear sets bringing the mill shaft speed down from 2000 r.p.m. to 70 r.p.m. Flexible couplings are fitted between the turbine and the high speed pinion shaft and also between the first and second reduction gears. The low speed gear is keyed directly upon the shaft of the flywheel shaft which carries a 23 ft., 100 ton flywheel, supported between two heavy bearings (25 pp., 7 figs.).

### INSTITUTION OF MECHANICAL ENGINEERS

*Advance paper C, read February 19, 1915, in London.*

Convertible Combustion Engines, Alan E. L. Chorlton

The author considers the question of design of convertible combustion engines, that is, engines which may be operated without essential alterations, on more than one kind of fuel.

At first sight, one might think that a combustion engine most ready to work on different fuels would be of the self-ignition type, with a cycle approximating to that of constant pressure and the only change necessary in going from liquid to solid fuel would be in the fuel injection device. In practice, however, owing to the difficulty with solid fuel injection, such a type would not prove workable and even when the fuel is first gasified, the results do not justify the complication. The problem of designing a convertible engine is better met by trying to combine known types for gas and oil in which good results are obtained at present and which, in general principles, show the same characteristics.

In the normal engines for both gas and oil, the chief difference lies in the degree of compression. There is no fundamental difference in engines for gaseous or liquid fuels except in their compression cycles, which shows that any schemes of convertibility must provide means whereby the requisite compressions can be obtained, but as there is a great gap between compressions of 100 lb. per sq. in. for a gas producer and 500 lb. in the case of crude oils, the tendency is, for practical uses, to combine the lower compression oil engine and the high compression gas engine and thus deal with a small compression pressure range. The desirable characteristics of a convertible engine are simplicity and reliability, high economy for each fuel, first cost as low as possible above that of the standard engine for each fuel, easy convertibility and as nearly as possible the same power for each fuel. The author divides all types of engines into three groups; first, engines of low compression and low power; second, engines of higher compression and higher power, and third, engines of maximum compression and high power.

*Group 1.* As an example may be taken the ordinary motor car engine, which has a compression up to 90 lb. per sq. in. and with slight modifications can run on several fuels. It is, however, designed for and works best on gasoline, fairly well but not so economically on city gas, requires very good kerosene and is not efficient at low compression with producer gas. If a more common kerosene or a good quality of crude oil is used, means must be provided whereby more heat is available for the ignition and combustion of the oil which can be done conveniently by the addition of an unjacketed portion to the cylinder end, when the engine becomes of the hot bulb type. Electric ignition is provided for gasoline as well as the kerosene, and good crude oil would be self ignited by the hot bulb. Fig. 7A shows such an engine for

small powers and it can be changed by unskilled labor from a gas engine working with a wood or coal producer to an oil engine, the governor requiring no adjustment for the full range of fuel. This type of engine is not suitable for any comparatively low powers and its range of fuels does not include anything heavier than good crude oil, and even its economy on oil is not high. *Group 2,* engines of higher compression and higher power, is represented by the Diesel engine with compression of over 500 lb. per sq. in. when using tar oils. Since a Diesel engine uses compression far exceeding the maximum compression for gas in a normally

*a* Engines working with a compression not exceeding 150 lb. for both oil and gas, and which may employ pocket firing with or without air injection for one, and electrical ignition for the other, or some combination, the smaller compression not involving material mechanical change of the parts.

*b* Engines working with a higher compression for oil than for gas, involving some modification of the combustion chamber by substitution of a part for oil as against a part for gas; otherwise maintaining the simplicity of both types.

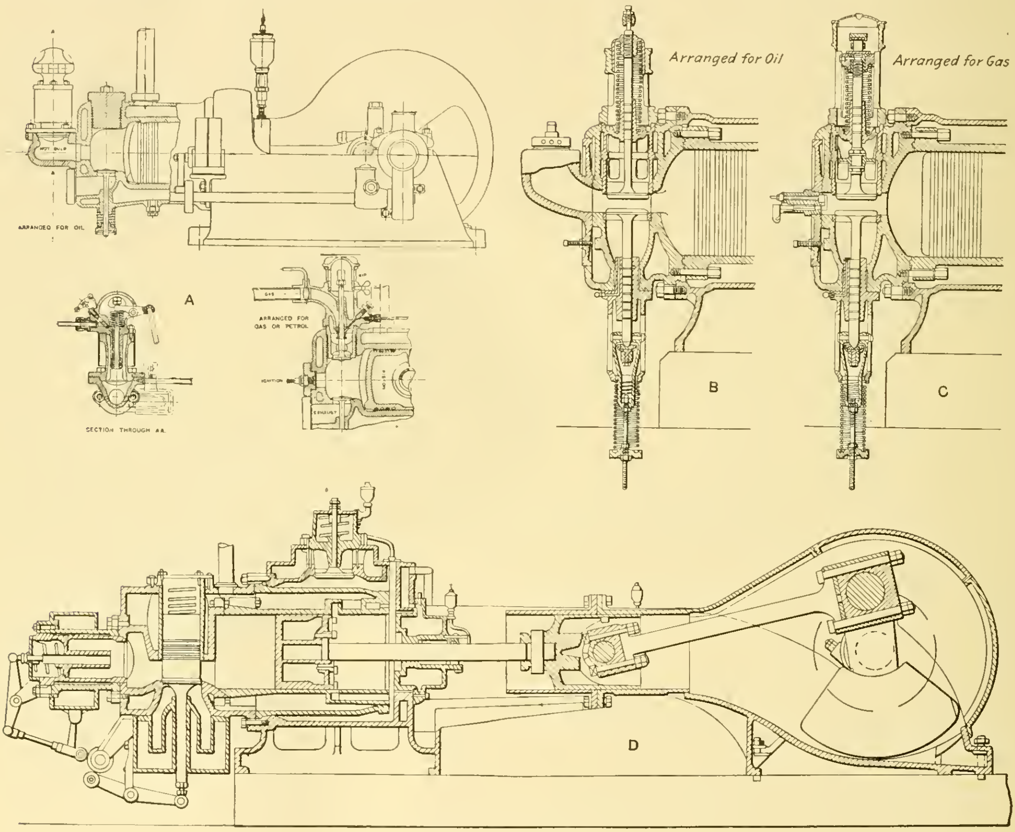



Fig. 7 Convertible Combustion Engines

used type of engine and in addition requires an expensive high pressure air pump, there is no commercial advantage in working it on gas.

Engines with a moderate compression suitable for developing higher powers, range in compression between 150 and 300 lb., a low range being suitable for most forms of producer gas but not usually exceeded because pre-ignition of the compressed charge is more prevalent in very high compression gas engines.

*Group 3.* Engines with a moderate compression suitable for developing higher powers. This group may be subdivided into four classes:

*c* Engines obtaining the necessary change from gas to oil, by temperature control of the air charge, together with alteration of the valve settings.

*d* Engines employing the super-compression of Dr. Dugald Clerk, to control effectively thereby the compression required for either fuel.

In sub-division *a,* there are a large number of engines which are used only for oil but might, without material alteration, become effective for the use of gas, as for example, a 2-cycle Bolinder engine shown in the original article. In sub-division *b,* the outputs in general figures for the engines on oil and gas appear to be very similar and so are the

diagrams actually taken. The possibilities of this type of convertible engine appear therefore quite great; in fact an engine is being made at the present time in considerable numbers, to fulfill these conditions, (Figs. B and C). In both cases, it presents the ordinary features of the four-cycle, the only change involved in converting from oil to gas being in the combustion bulb of the oil engine in changing from an oil type to a gas type of piston.

As to class *c*, it is mechanically convenient but not quite efficient, as the author attempts to prove. In class *d*, the Clerk super-compression engine is a promising type for dealing with the variable compression problem of the convertible engine. In it, Fig. D, an extra charge of air or inert gas is added to the working mixture at the end of the suction stroke. By this "watering" of the charge much lower maximum flame temperatures are obtained and a higher mean cylinder pressure rendered possible. Further, the compression can be adjusted between wide limits. The conclusion at which the author arrives is that for powers up to say 1000 h.p., engines of the type shown in Fig. B and C are the most suitable as convertible engines while for the larger powers, when tandem engines and size and weight of removable parts become a problem, the Clerk super-compression type offers a hopeful possibility (15 pp., 13 figs.).

*The Journal, No. 2, February 1915*

The Steady Flow of Steam through a Nozzle or Throttle, Professor H. L. Callendar (abstracted)

Standardization of Pipe Flanges and Flanged Fittings, John Dewrance (abstracted from Advance Paper in *The Journal*, March 1915, p. 189).

On the Steady Flow of Steam Through a Nozzle or Throttle, Professor H. L. Callendar.

In the course of some experiments on the law of condensation of steam previously undertaken by the author, in which the temperatures of steam during adiabatic expansion and compression were observed with a very sensitive platinum thermometer in the cylinder of a steam engine, it was found that the index $m$ of the adiabatic equation $PV^m =$ constant was very nearly independent of the pressure and temperature, and equal to 1.30. This result, at first sight, seemed discordant with the wide variations of the specific heat as shown by other experiments made at the same time, but was later on explained by the author's theory. The temperature measurements also showed that during rapid adiabatic expansion, the temperature of steam might fall appreciably below the saturation temperature, indicating a state of supersaturation in the cylinder. The practical importance of this state of supersaturation increases in proportion to the rapidity of the expansion, and becomes considerable in the case of expansion through a nozzle.

The object of this paper is to apply the equation for supersaturated steam to the problem of flow of steam through a nozzle or throttle.

The author objects to the formula commonly employed on various grounds, in particular, because steam cannot condense reversibly in the time taken to reach the throat of the nozzle, and the adiabatic equation for wet steam does not apply, therefore, to the maximum discharge determined by the state in the throat. Dry steam, when cooled by rapid expansion beyond the saturation point, does not condense unless suitable surfaces or nuclei are present to start the condensation, and when issuing from a jet, does not appear cloudy for an appreciable space beyond the throat. It is physically impossible that any material condensation should occur in the time occupied in reaching the throat of the jet, which is generally of the order of 0.0001 second. The adiabatic equation which applies to the discharge, therefore, is not that of wet steam but that of dry steam, superheated or supersaturated. According to the author's equation, the appropriate value of the index $m$ is 1.30, which agrees much better with observations of the discharge than the value 1.135 for wet steam commonly employed. The author points out, however, that it would not be justifiable to use this equation if it had not been shown by theory and experiment that it was thermodynamically consistent:

1. with the characteristic equation
2. with the cooling effect in expansion through a throttle
3. with the variation of the specific heat
4. with the equation of saturation pressure

and claims that the correspondence of his formula in all these cases is thermodynamically exact.

*Equations for discharge of superheated or supersaturated steam* according to the author's equations, the relation between $P$ and $V$ in the adiabatic expansion of dry steam, whether superheated or supersaturated, is

$P^n\ (V-b)^{n+1} =$ constant, or $P\ (V-b)^m =$ constant, where $m = 1 + \frac{1}{n} = 1.30$.

The small constant $b$ is the volume of the liquid at low temperatures, namely, 0.0160 cu. ft. per lb. or 0.001 cbm. per kilogram.

The corresponding expression for the total heat, $H = E + aPV$, is

$$H = a(n+1)\ P\ (V-b) + abP + B,$$

where $B$ is a constant having the value 464.0 calories on the Centigrade system, or 835.2 B. t. u. on the Fahrenheit system, and $a$ is the numerical factor reducing PV to heat units.

These equations may be combined with the equation of flow $kUX = WV$, and the thermodynamical relation $\frac{U^2}{2g} = J(H_0 - H)$, to determine the maximum discharge in adiabatic flow, in the following manner.

The condition that the flow $W$ is to be a maximum for a given value of the throat section $X$, or that $X$ is to be a minimum for a given value of $W$, gives immediately the simple relation,

$$\frac{dU}{dV} = \frac{U}{V}$$

Eliminating $\frac{dU}{dV}$ by differentiating the equation $\frac{U^2}{2g} = J\ (H_0 - H)$, we find

$$\frac{-U^2}{JgV} = \frac{dH}{dV} = a(n+1)P + a(n+1)\ (V-b)\left(\frac{dP}{dV}\right) + ab\left(\frac{dP}{dV}\right)$$

Substituting the value of $\frac{dP}{dV} = \frac{-mP}{V-b}$ from the adiabatic equation, we obtain

$$\frac{U^2}{V^2} = \frac{amJgP}{V-b}$$

which is the exact expression for the velocity of sound in the vapor in the state $(P, V)$, and differs from the expression usually given only by the small quantity $b$, which is commonly neglected. This term is theoretically required, even

in the case of hydrogen, the most perfect of all known gases, in order to explain the Joule-Thomson heating-effect, which is of great practical importance in the liquefaction of hydrogen. It is also required to explain the limit of compressibility of gases, and the increase of the velocity of sound for intense disturbances. Since, however, $b$ is very small, and its exact value necessarily uncertain, the equation may be reduced to the simpler form,

$$\frac{U^2}{Jg} = amP(V+b)$$

which gives the throat velocity in terms of $P$ and $V$ in the throat.

The primary effect of supersaturation in the throat of a nozzle is to increase the discharge by about 5 per cent as compared with that calculated on the usual theory with a given throat area. The secondary effect is to cause an increase of entropy and volume when the steam becomes wet after passing the throat. The two effects require, for a given throat area and ratio of initial to final pressure, an increase of 6 to 8 per cent in the final area of the cone, or an increase of length of 3 to 4 per cent in the diverging cone for a given angle of divergence.

The effect of friction in the throat is to reduce the discharge by a small fraction, which appears to vary inversely as the initial pressure, and inversely as the throat diameter for similar nozzles. The order of magnitude of this fractional reduction, for a well-designed nozzle with smooth contours, appears to be given by the formula $\frac{1}{P_o D}$, where $P_o$ is the initial pressure in pounds per square inch absolute, and $D$ the diameter of the throat in inches.

The effect of friction beyond the throat increases with increase of velocity and diminution of final pressure, and may be estimated with some degree of probability by taking the percentage loss of heat-drop to be proportional to the heat-drop itself. The diminution of velocity and increase of volume due to friction may require an increase of 10 to 20 per cent in the final area, equivalent to an increase of lengths of 5 to 10 per cent for a given angle of divergence, as compared with the length calculated for the case of frictionless flow.

## ROYAL SOCIETY

*Proceedings, Ser. A, vol. 91, no. 623, London.*

ON THE FLOW OF VISCOUS FLUIDS THROUGH SMOOTH CIRCULAR PIPES. Charles H. Lees

The article discusses the problem of the flow of a viscous fluid through tubes of circular section, especially smooth tubes, and in the introduction gives a review of the work previously done in this connection.

The Principle of Dynamical Similarity shows that for the flow of viscous fluids through pipes, if for a number of cases $\frac{vd}{\nu}$ has the same value (where $v$ is the speed, $d$ the diameter of the pipe and $\nu$ the kinematical velocity), then for the same cases $\frac{R}{\rho v^2}$ will have the same value, where $R$ is the resistance per unit surface of contact of fluid and pipe, and $\rho$ the density. Hence, if $\frac{vd}{\nu}$ be taken as the abscissae and $R$ as the ordinates, every case of motion of a viscous fluid through a pipe will be represented by a point of the diagram and all of the points will lie on a curve, if the principle is strictly applicable to such cases, or will cover a strip, the width of which will increase as the applicability of the principle decreases. The observations made by Stanton and Pannell on the flow of air and water through pipes show that if $v$, the velocity, be taken as the mean velocity over the whole section of pipe, the locus of the points in the diagram is a narrower strip, the width of which is only of the order of the errors of experiment and that for cases in which $\frac{vd}{\nu}$ is the same, the law of distribution of velocity over the cross section is the same. The author proceeds to the determination of the simplest form of the function $\varphi$ in $R/\rho v^2 = \varphi\,(vd/\nu)$ which would embody the results of Stanton and Pannell on one side and of Saph and Schoder on the other side. He obtains the following expression

$$R/\rho v^2 = 0.0009 + 0.0765\ (v\ d/\nu)^{0.35}$$

or

$$R = \rho v^2\ [0.0765\ (\nu/vd)^{0.35} + 0.0009] = \rho\ [0.0765\ (\nu/d)^{1.65}\ v^{1.65} + 0.0009\ v^2]$$

and since this expression satisfies the principle of similarity, it has been shown to hold for the mean speed of flow of air and water through pipes of diameters between 0.3 and 12 cm. The constants of the above equation hold over the whole of this range at least, and probably this type of relation with a small change of the constants will apply over a much wider range. The author proceeds to the development of a formula expressing not $R$, the resistance per unit area of surface exposed to the fluid, but the fall of pressure $p_o - p_1$ along a given length $l$ due to it, by reproducing, side by side, the observations of Stanton and Pannell with a line showing the values deduced from his expressions and shows the close agreement between the two. The form of the final expression for the fall of pressure along the tube indicates that this fall will, for all velocities, be approximately proportional to the power of the velocity between the 1.65th power and the square, and that as the speed of diameter increases or the kinematic velocity decreases, the law of variation will approximate more and more closely to the second power. The further conclusions arrived at, are summarized by the author as follows:

*a* The difference of pressure $p_o - p_1$ in dynes per square cm. between two sections distant 1 cm. from each other along a pipe of diameter $d$ cm. through which a fluid, whose density $\rho$ may be considered constant over the length $l$ and whose kinematical viscosity is $\nu$, is flowing with mean velocity $v$, cannot be represented by a single power of the velocity but requires for its expression a formula of the type

$$p_o - p_1 = l\rho\ v^2/d)\ (a - b\ (\nu/vd)^n)$$

where $a$, $b$, and $n$ are constants.

*b* To the extent to which the Principle of Dynamical Similarity is applicable to the flow of fluid in tubes, $a$, $b$, and $n$ should be absolute constants applicable to all fluids and all tubes. Stanton and Pannell's results show that over a wide range $a = 0.0018$, $b = 0.153$ and $n = 0.35$

*c* As the velocity and diameter increase and as the kinematical viscosity decreases, the pressure difference varies more nearly as $l\rho v^2/d$.

*d* The effect of temperature on the pressure difference decreases as the velocity and diameter increase and as the kinematical viscosity decreases. (8 pp., 1 fig. *t.*)

# MEETINGS

## MINNESOTA, FEBRUARY 12

The regular February meeting of the Minnesota Section was held in the offices of the St. Paul Gas Light Company at which Professor Stewart of the Minnesota Agricultural College gave a talk on Triangulation. He showed a number of slides which illustrated some work on Triangulation which he had done for the Government in some of the western states a few years ago.

## ST. LOUIS, FEBRUARY 16

At a meeting of the St. Louis Section on February 16, a Committee was appointed to draw up a tribute to the late Col. Meier which is presented herewith:

In the death of Col. E. D. Meier, the local section of the Am. Soc. M. E. has lost a staunch supporter, adviser and friend.

Although the later years of his life were spent in New York he was a personal friend of many of us and admired by all for in him was combined a charming personality and rare technical ability.

He was a man of great originality and tireless energy, sparing not himself in the promotion of either his own ideas or those of others if he believed them good.

It was largely through his efforts that the local section idea was adopted. To him were due many improvements in his own particular field. Practically to him alone is due the inauguration of the most important movement ever undertaken by the American Society of Mechanical Engineers—the Uniform Boiler Code. If adopted this will do more than any other has done to promote safety from boiler explosions and the consequent conservation of life and property.

We have lost a valued friend, the country a good citizen and the profession an able engineer.

Respectfully submitted,

E. L. Ohle,
E. R. Fish,
Edw. Flad,
*Committee.*

## BUFFALO, FEBRUARY 25

At a meeting of the Buffalo Engineering Society on February 25, which the members of the Employers Association, the Chamber of Commerce and other Industrial Associations of Buffalo had been invited to attend, M. W. Alexander of the General Electric Company spoke on The Waste in Hiring and Discharging Employees. A very interesting statement that he made after working out the figures on the blackboard showed that in an average of thirteen plants, where 8000 employees had been added to the payroll during the year, over forty-six thousand had been hired and discharged in obtaining the increase of 8000. Based on a very conservative allowance, Mr. Alexander claimed that in the neighborhood of 26,000 of the total number hired were unnecessary, and that the cost of hiring and discharging this 26,000 amounted to over $880,000. After presenting these figures, he gave a very complete explanation of the ideas which have occurred to him in studying this problem, which he has carefully worked out to avoid a considerable amount of this waste.

## CINCINNATI, FEBRUARY 25

On the evening of February 25, the members of the Cincinnati Section gave a dinner in honor of Calvin W. Rice, Secretary of the Society. Following the dinner, Mr. Rice was introduced to the joint meeting of the Cincinnati Section and of the Engineers' Club of Cincinnati, to whom he made an address describing the trip of the Society to Germany in the summer of 1913. Mr. Rice began by recounting the very careful preparations that were made for this trip. Before beginning the journey, members were furnished with itineraries giving a complete description of the various places of interest they were to visit. So painstaking was the preparation that members of the party knew not only the hotel for which accommodations were provided for them, but even the numbers of the rooms to be occupied. Mr. Rice described the life on board the ship, the meeting of the reception committee before European shores had been reached, the reception in Hamburg and a series of entertainments given by the engineers of Hamburg, Leipzig, Cologne, Düsseldorf and other cities. He described in detail some of the more remarkable establishments visited, illustrating their principal features by lantern slides.

## BOSTON, FEBRUARY 26

A joint meeting of The American Society of Mechanical Engineers, American Institute of Electrical Engineers and Boston Society of Civil Engineers was held at Wentworth Institute, Friday evening, February 26.

Wentworth Institute was founded 3½ years ago for training workmen of the most competent and expert type, foremen and master mechanics, and has grown so rapidly that there are nearly 1300 pupils enrolled in its day and evening classes. This meeting gave an opportunity for the inspection of the new shops and laboratories which are admirably adapted to the special purposes of instruction for which they were planned, with most complete equipment. After a buffet supper the audience gathered in the assembly hall for the formal program upon the general subjects of the training and education of employees and the relation of the employer to his men and their education. There were over 200 present at the meeting and the addresses of all the speakers were very much appreciated. The several papers were as follows: The Responsibility of the Manufacturer for Training of Foremen and Skilled Workmen, by Walter C. Fish, general manager Lynn Works, General Electric Co.; The Employer's Side of the Problems of Irregular Employment, Henry S. Dennison, treasurer, Dennison Manufacturing Co.; Coöperation Between Employers and the Schools, William B. Hunter, director of Fitchburg Industrial School; The Economic Relation Between the Supply of Skilled and Intelligent Workmen and Unemployment of the Masses, Prof. Thomas N. Carver of Harvard University. It is expected to publish an account of these papers in a later issue.

## NEW YORK, MARCH 9

At the monthly meeting of the Society in New York held on March 9, Dr. Hollis Godfrey, President of the Drexel Institute of Philadelphia, presented an address on the Application of Engineering Methods to the Problems of the Executive, Director and Trustee. Dr. Godfrey, who has served in his experience two municipalities, and a number of corporations having a large number of employees, has found that it is very necessary to be explicit, and to put various problems in writing so that the Board of Trustees or Managers could determine at a glance how to proceed. He has had to select the facts which were to be studied and after collecting and studying them, to translate them and

lastly to express them in such fashion that the executive can use them effectively for the different purposes for which an executive needs to use such material. Dr. Godfrey considers that it is peculiarly the duty of a consulting engineer concerned with facts to present them clearly and briefly in the three cases, in the case of the presentation to the board, in the case of the education of the staff and in the case of the education of the public.

Dr. Godfrey illustrated his paper with charts which showed graphically the problems with which he has had to deal and the results that he has obtained. A very interesting and lively discussion followed the presentation of the paper.

### BUFFALO, MARCH 11

A meeting of the Buffalo Engineering Society was held on March 11. The meeting was addressed by Prof. C. F. Hirshfeld of Detroit on Interesting Features Involved in the Design of the Connors Creek Plant of The Edison Illuminating Company of Detroit. Lantern slides were used to show the geographical outline of the city of Detroit upon which the general distribution of power was indicated by the location of the sub-stations and the reasons explained for locating the new power plant at Connors Creek. Various views were also shown of the location of the plant and of the plant itself at the various stages of construction. The views were also shown giving a cross-section outline of the boiler house, turbine room and electrical power unit and a full explanation was given on the operating of the various parts of this machinery, which showed that a careful estimate has been made covering every detail of the power generation and consumption. All this has probably been worked out in more detail than any other plant which has been built in this country, and consequently the overall thermal efficiency of the plant as a unit is expected to equal if not to exceed any similar power plant which has ever been built.

About 150 members were present at the meeting and a large number of them entered into a discussion of Professor Hirshfeld's paper.

### CINCINNATI, MARCH 18

A joint meeting of the Cincinnati Section of The American Society of Mechanical Engineers and of the Engineers' Club of Cincinnati was held on March 18. Theodore H. Schoepf, of the Westinghouse Company, gave an address on The Electric Commercial Vehicle. The speaker confined his remarks entirely to electric trucks. He began by describing the conventional design of the electric truck, and illustrated by slides the position of the battery box, the motor, the gearing of the latter, the steering gear, and the location of the brakes. He stated that the 1000 lb. and 4000 lb. trucks were the most popular, and that the use of such trucks was growing by leaps and bounds. After showing by various views and line drawings, the conventional design of the electric truck, some interesting departures from the conventional design were illustrated and discussed. A balanced-drive truck, in which gears are contained within wheels with solid webs and the entire motor and differential are contained in a hollow cast rear axle, was given considerable attention.

The speaker dwelt at length on the economy attending the use of electric trucks, quoting liberally from statistics tabulated in Chicago, Boston and New York. The range of speeds and distances per day within which the electric truck is most effective were discussed, the speaker admitting that, beyond a certain range, the electric vehicle could not compete with the oil-driven machine. He concluded his address with descriptions of some of the motors used on electric vehicles, which motors ranged from 70 to 90 lb. h.p. and had a great overload capacity, a maximum efficiency of between 85 and 90 per cent and a long range of high efficiency.

## NECROLOGY

#### WILLIAM ALEXANDER CHERRY, JR.

William Alexander Cherry, Jr., was born in Denver, Colorado, in October, 1888, and was graduated from Columbia University in 1911. During the summer of 1909 he served a machine shop apprenticeship with the Acme Machine Company of New York and a power plant apprenticeship with the New Rochelle Light and Power Company of New Rochelle during the summer of 1910. After his graduation from Columbia he became associated with Viele, Blackwell and Buck, of New York, Consulting Engineers. While with them he worked on several designs such as hydraulic power stations and machines for a new Gas Producer. He was also employed in the laboratory on the practical end of the above process in testing out various materials to be used in the manufacture of producer gas.

For the past two years Mr. Cherry has been connected with the Florida Abstract and Title Insurance Company of Jacksonville, Florida. He died in Atlanta, Ga., on March 6.

#### HENRY G. MORRIS

Henry G. Morris was born in Philadelphia May 25, 1839 and graduated from Haverford College. He engaged in active manufacturing business in early life, and when still a very young man was a member of the celebrated firm of Morris, Tasker & Co., who were the first manufacturers of wrought iron pipes and boiler flues. A few years later he became the sole owner of the Southwark Foundry, where some of the largest blowing engines, pumps and other heavy machinery were constructed, and at that time was justly regarded as one of Philadelphia's greatest captains of industry. Mr. Morris was one of the first Directors of the Pennsylvania Steel Company, and was one of the few men in this country, like Alexander Lyman Holley, to recognize the importance and value of the Bessemer process. He was a leader in the design and manufacture of the most diversified kinds of machinery used on sugar plantations and in refineries, gas plants and water works, and among the first in this country to recognize the value of compound engines in marine engineering.

He early became interested in electrical engineering, and will undoubtedly be best remembered in connection with Mr. Salom in the invention and development of the Electric Vehicle for which, twenty years ago, they received the gold medal of the "Times-Herald" Motocycle contest in Chicago, 1895 (the birth of the automobile), and the John Scott Legacy Medal of the Franklin Institute, Philadelphia. He took out numerous patents in connection with the same and for storage batteries.

He was a member of many national societies and associations, including the American Society of Mechanical Engineers, of which he was a past vice-president; The Engineers

Club of Philadelphia, of which he was a past president; The American Institute of Mining Engineers, The American Society of Civil Engineers, The Franklin Institute of Philadelphia, and the Union League of Philadelphia, of which he was the oldest living member in point of time with a single exception. He was elected a member February 14, 1863. Mr. Morris died on January 19.

#### FREDERICK WINSLOW TAYLOR

Frederick Winslow Taylor, Past-President of The American Society of Mechanical Engineers, died in Philadelphia on March 21. He was born in Germantown, Philadelphia, in 1856. His primary education was obtained in this country and in France and Germany. By night study he secured the degree of Mechanical Engineer from Stevens Institute of Technology.

He served apprenticeships in pattern making and at the machinist's trade in Philadelphia, and began practical work in the shops of the Midvale Steel Company in Philadelphia, where in six years he worked up to the position of chief engineer. Beginning here and continuing later at the works of the Bethlehem Steel Company, he made a scientific study of labor problems and efficiency and put into operation principles of scientific management which have since received world wide attention and application in many industrial organizations. Incidentally, this work led to the study extending over a period of 26 years of the laws of cutting metals; and the development of the Taylor-White process for the heat treatment of steel for cutting tools.

A more complete account of his life, with appreciations of his career, appear in another part of this issue of The Journal.

## PERSONALS

Louis M. Zach has become associated with the engineering department of the Anaconda Copper Co., Anaconda, Mont. He was until recently mechanical engineer with the Doe Run Lead Co., Rivermines, Mo.

Thomas A. Bennett, who for the past five years has had charge of the conveyor and elevator belt sales of the B. F. Goodrich Co., Akron, O., has severed his connection with that company and has become the assistant to the general sales manager of the New Jersey Zinc Co., with offices in New York City.

Stephen G. Luther is now connected with the alkali division of the Philadelphia Rubber Works Co., in Akron, O., as manager of the experimental department. He was formerly located at the Philadelphia factory of the company.

J. E. Woodwell announces the dissolution of his partnership with L. B. Marks and will locate at 8 W. 40th St. about May 1, where he will continue the general practice of consulting engineering.

Clarence M. Davison has resigned his position as assistant chief engineer of the Kennedy Stroh Corporation, Oakmont, Pa., and has accepted the position of general manager of the Westbrook Elevator Company, Danville, Va.

Louis T. Sicka has resigned his position as mechanical superintendent of the Tooele Plant of the International Smelting Company, Tooele, Utah, and has accepted the position of mechanical superintendent and engineer for the St. Joseph Lead Co., Bonne Terre, Mo.

Wm. F. Gillies has become manager of the Ingersoll-Rand Co., Pittsburgh, Pa. He was until recently New York branch manager of the A. S. Cameron Steam Pump Co.

Joseph L. Gilson has severed his connections with the De La Vergne Machine Co. of New York, and has accepted a position with the Arctic Ice Machine Co., Canton, O.

Henry R. Towne has retired as president of the Yale & Towne Manufacturing Company, a position which he held for 46 years, and has been elected chairman of the board of directors. To fill the vacancy created by Mr. Towne's partial retirement from the activities of the company, the directors have elected as president, Walter C. Allen, until recently vice-president and general manager of the company.

Frederick Ray has recently opened an office at 50 Church St., New York, as Consulting Engineer, where he will make a specialty of centrifugal pumping machinery, condensing equipment, cooling towers and similar apparatus.

Charles H. Schmalz is manager of the Billings Foundry and Manufacturing Co., Billings, Mont. He was formerly associated with the Boston and Montana Reduction Department of the Anaconda Copper Mining Co., Great Falls, Mont., as assistant master mechanic.

## STUDENT BRANCHES

#### ARMOUR INSTITUTE OF TECHNOLOGY

A meeting of the Student Branch of Armour Institute of Technology was held on March 11 at which the following officers were elected: G. F. Gebhardt, honorary chairman; J. M. Byanskas, president; B. S. Carr, vice-president; E. S. Echlin, secretary; L. Luckow, treasurer.

G. F. Wetzel, '12, read a paper on paints used on engineering work. The paper contained a description of the constituents of the paints used on structural work and similar engineering work. Formerly it was taken for granted that any kind of paint would do, but now large buyers test paint submitted before purchasing. In government work, the paint has to conform to the standard formulæ worked out in the testing department.

#### BROOKLYN POLYTECHNIC INSTITUTE

The Polytechnic Institute of Brooklyn Student Section held its regular monthly meeting on March 6, at which Dr. Magnus C. Ihlseng, consulting professor of Works Engineering at the Polytechnic Institute, gave an illustrated talk on Coal Mining. The speaker outlined the methods pursued in mining, the ventilation safety methods and the costs of the different grades of coal.

V. N. Hewlett, a student, read a paper on Modern High Speed Automobile Motors, showing the progress made since 1907 in automobile motor design, with special reference to the different types of valves which have been perfected.

Since January 15, excursions have been made to the following places of interest: January 16, Hecker-Jones-Jewell Milling Company, New York City; February 20, Nicholas Power Company, manufacturers of moving picture machines, New York City; February 27, Morse Drydock and Repair Company, South Brooklyn; March 6, Power Station of the New York Central Railroad at Port Morris.

During the spring vacation of the Institute, an inspection trip will be undertaken by members of the Branch, including the cities of Cleveland, Detroit, Chicago, Cincinnati and Pittsburgh.

At this meeting the resignation of the secretary of the Branch, Samuel Kobre, was accepted and George A. Wieber was elected to take his place for the remainder of the present year.

#### CARNEGIE INSTITUTE OF TECHNOLOGY

The regular meeting of the Carnegie Student Branch of The Am. Soc. M. E. was held at Machinery Hall on February 10. W. C. Stevenson, C.I.T. '08, read a paper on The Mechanical Engineering Involved in Erecting an Electrically Driven Bar Mill, at the Duquesne Works of the Carnegie Steel Company. He gave a detailed account of many of the problems which had been solved in the erection of this mill,

and described its peculiar features. For instance, the rolling of the bar is entirely automatic, no catchers being used. Mr. Stevenson illustrated his talk with the blue prints which had been used in the construction of the mill. The paper was discussed by Professor Trinks.

### COLORADO AGRICULTURAL COLLEGE

At a meeting of Colorado Agricultural College Student Branch on February 17, the article by F. R. Low in the October issue of The Journal on Pulverized Coal for Steam Making, was reviewed by T. H. Sackett. His talk brought out the economical use of pulverized coal as compared with lump coal. This was followed by a general discussion.

Mr. Murray gave an interesting talk on Safe Steel Rails, and placed emphasis on the numerous tests made to determine flaws and the method of eliminating them.

At a meeting on February 26, Large Steam Power Plants was the subject of an instructive talk by Mr. G. G. Law. His subject covered the work in the whole plant, but more especially the boiler room and the new appliances used there. At the close of the paper Mr. Law answered several questions on his subject.

Mr. Morrison discussed the paper on Industrial Service in Engineering Schools by J. W. Roe, which appeared in the June issue of The Journal. He gave a history of the work and then spoke of the problem of Americanizing the laboring immigrant. Professor Crain spoke briefly on the same subject, comparing the ordinary reform methods with those in the line of industrial reforms. He brought out clearly the practical side of the subject and showed how the men could help to solve the problems of capital and labor. Mr. Stephens discussed briefly the subject of Industrial Service Work which he himself had seen in Chicago.

### KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch on February 4, E. Lee Heidenreich, a consulting engineer of Kansas City, Mo., addressed the Branch on Reinforced Concrete in some Engineering Branches. Mr. Heidenreich gave a short history of the use of concrete, especially the Monier construction or, as it is now known, reinforced concrete. The speaker advocated a more extensive use of concrete in all types of construction, its greatest value being that it is almost fire and water proof. Mr. Heidenreich discussed the use of reinforcing and some of the advantages and disadvantages of the forms now in use. He personally preferred steel of high elastic limit from 50,000 to 55,000 lb. per sq. in., avoiding twisted square bars and using bars with the deformations at right angles to the axis of the bar.

On March 4, H. R. Setz, a member of The Society and Chief Engineer of the Fulton Iron Works, St. Louis, gave an illustrated lecture on the Development of the Diesel Engine. Mr. Setz has had experience in Europe with the earlier types of Diesel Engines. He very clearly pointed out defects in the first non-jacketed types and also the impracticability of using the same valve for controlling the inlet and exhaust events. By means of original diagrams he illustrated the difference in temperature between the actual Diesel diagram an dthe ideal Diesel engine.

### KANSAS UNIVERSITY

The regular weekly meeting of the Kansas University Student Branch was held on February 25, at the home of Dean P. F. Walker. Floyd Nutting gave a description of the water-power development at Keokuk, Iowa. Mr. Nutting visited this plant in November 1914, and spoke chiefly from notes taken at that time. After describing the dam and power house equipment, he spoke of the service and transmission lines with particular reference to the power furnished the city of St. Louis. He also gave some ideas of the size and construction of the government locks at the Keokuk dam.

B. O. Bower spoke on the Kansas City Automobile Show, which was held February 8 to 14, 1915. He told of the tendencies in design which 1915 cars are following, and compared in some detail the motor part proportions of the new cars with those of earlier models and explained the reasons for the changes.

### LELAND STANFORD UNIVERSITY

At a meeting of the Leland Stanford Mechanical Engineering Association on February 9, the resignation of H. M. Henderson as secretary of the Branch was accepted, and C. L. Addleman was elected to fill the vacancy.

Prof. W. F. Durand addressed the society on ways of making the meetings for the present semester a success. An illustrated talk on Automobile Foundry Work was given by B. M. Green, President of the Branch. The speaker laid emphasis on the arrangement of molds and conveyors in the modern shop. The slides showed the Ford foundry and a large jobbing foundry.

### MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On February 24, at a meeting of the Massachusetts Institute of Technology Student Branch, Mr. Gillespie of the United Shoe Machinery Company of Beverly, Mass., gave a very interesting talk, illustrated by moving pictures, on From Pelt to Welt, in which he took up the complete process of making Goodyear welt shoes. Mr. Gillespie gave the history of the shoe as one of the garments of man and traced its development from 4000 B.C. to the present time. He showed pictures of many of the old types of shoes, and compared some of the very earliest shoes with the shoes now worn by the Mexican army, showing the close resemblance. The speaker also told of the development of the royalty system used by the United Shoe Machinery Company today, and showed pictures of some of the company's welfare work.

### OHIO STATE UNIVERSITY

On February 27, Calvin W. Rice, Secretary of The Society, addressed the members of the Ohio State University Student Branch on the 1913 Trip of the Am. Soc. M. E. to Germany. Before touching this subject, however, Mr. Rice spoke briefly of The Engineering Foundation, the coming meetings of the Society, The International Engineering Congress, and The Pan American Congress to be held in Washington. The excellent library facilities which the Society offers to its members were mentioned, also the purpose and object of the Student Branches was reviewed.

In speaking of the future of the engineering profession, Mr. Rice stated that it was certain to supplant the influence of the lawyers and doctors as leaders of men; and that the future engineer would cease to deal with things entirely and would deal more and more with men and would thereby become more prominent in politics and in the progress of established communities. Mr. Rice pointed out the extreme difficulty the United States was having and would have in maintaining her neutrality, and advocated the establishment of a civilian engineering reserve corps to assist the work of the war department in the defense of our coast cities.

The talk on the 1913 trip of the Society to Germany was illustrated by numerous excellent lantern slides, which impressed one with the wonderful organization of the German nation, the sincere and genuine hospitality which it extended to the American visitors and also with the high public esteem which the engineering profession there enjoys.

### PENNSYLVANIA STATE COLLEGE

The new officers of the Pennsylvania Student Branch were installed at a meeting on February 12. William Blume read a paper on the Diesel Engine, giving an interesting and detailed account of the construction, operation and charactertistics of the Diesel Engine together with a biographical sketch of Rudolf Diesel.

On March 4, there was a special literary meeting. A paper on the Keeler Boiler was read and illustrated with stereopticon slides which were furnished by the Eugene Keeler Company.

### PURDUE UNIVERSITY

At a meeting of the Student Branch of Purdue University on February 9, the following officers were elected for the

second semester: B. J. Davidson, chairman; R. T. Gray, vice-chairman; O. F. Hambrock, recording secretary; V. P. Craig, corresponding secretary; J. M. Lonn, treasurer. J. W. Trimmer, '15, gave an illustrated lecture on Air Brakes.

At a meeting of this Branch on February 23, E. G. Stradling, signal engineer with the Monon Railroad, gave a paper on Signal Engineering and Apparatus. He said that the art of signaling as applied to steam and electric railways is divided into two general classes. These are known as interlocking signaling and block signaling. As the word implies, the term interlocking when applied to signaling means that certain switches and signals are so inter-connected with one another, that they must be operated in a pre-determined sequence. Interlocking is used for the protection of trains in their movements at railroad crossings at junction points and at points where there are several switches used by a large passenger terminal. The well known term of block signaling means that a railroad between certain points is divided into short sections of a desired length, each section known as a block and the entrance of a train into each block is regulated by a signal of some design.

Today for a simple crossing of two single tracks, we have on each track approaching the crossing a derail located in most cases five hundred feet from the crossing. Fifty-five feet beyond this is located the home or positive stop signal and farther out some three or four thousand feet is located the distant or caution signal. All of the derails with their locks and all of the signals are controlled by levers grouped together in a tower near the crossing. These levers are controlled by one man and are all normally placed in the position which has all derails set against traffic and all signals set so as to stop all trains. The levers which control these respective functions of the plant are so connected mechanically that not any one of the caution signals can be moved to the proceed indication for a train until its respective home signal has first been moved to the proceed position. Neither can the home signal give the proceed indication until both the derails on that track have been set and locked for the passage of the trains, and with the first movement of the levers that set the derails for a passage of the train on that track, the derail levers for the other track are locked in their normal position so that neither they nor the signal on that track can be moved but must remain in a position to oppose traffic. From this simple plant with its twelve or fourteen levers, one can go to the plant in some of the new passenger terminals, one of which has over four hundred levers.

Block signaling as defined by the Inter-state Commerce Commission consists of a scheme for maintaining a space interval between trains as distinguished from the train rule system of attempting to maintain a time interval. This can be accomplished either by a manual block system or an automatic block system. The manual block system which was first introduced on the American railways in about the year 1863, requires the coöperation of two men for each block, generally telegraph operators, one of whom notifies the other when a train enters the block while the second notifies the first as soon as the train has passed out, so that the first operator may permit a second train to enter.

In the year 1879, the track circuit was introduced and thus began the development of the automatic block signal system. The track circuit consists of a source of electric energy, usually a primary battery connected one pole to each of the two rails of the track, using the rails as conductors and of a relay connected between the rails at the outer end of the circuit. The presence of a train on the rails will shut the circuit and open the relay, likewise any interruption to the circuit from a broken rail or open switch will cause the relay to open. By the control of the secondary circuit through this relay, it is possible to operate the block signals in any manner that may be desired.

### STEVENS INSTITUTE OF TECHNOLOGY

On Wednesday, February 17, the Student Branch of The Am. Soc. M. E. of Stevens Institute of Technology conducted an inspection trip to the Crucible Steel Company, in Harrison, N. J. The party was made up of about twenty students who were guided through the plant and shown the three processes employed by the company in the manufacture of chrome, nickel and tungsten steels: the open hearth, the electric furnace and the crucible methods.

The following Wednesday, the Stevens Engineering Society visited the Keuffel and Esser factory in Hoboken to see the manufacture of drafting and surveying instruments. The trip through the plant was very instructive, but the party was prohibited from inspecting the secret processes, such as the graduation of the Keuffel and Esser slide-rule. The periscope which was being constructed in the factory at the time of the trip was of particular interest because of the recent German submarine raids on the English coast.

On Friday of the same week, Charles H. Day of the Aircraft Company, at Bound Brook, N. J., gave a further insight into machines of war, by a lecture on the Engineering Principles of Aeronautics. Mr. Day, who has had much experience in the building and flying of aeroplanes, was in an advantageous position to talk from the birdman's point of view. The most remarkable of his statements was that about nine out of every ten flying machines built in the United States have been built without a stress diagram.

### UNIVERSITY OF CALIFORNIA

At a meeting of the Student Branch of the University of California, A. C. Moorhead gave a paper on State Liability And Compensation Insurance. The paper was discussed by Prof. R. S. Tour, Rene Guillon, H. L. McLean and Robert Christy.

H. L. McLean read a paper on Valuation of Public Utilities. It was discussed by Professor Tour, Rene Guillon, Charles Ball, A. C. Moorhead and Robert Christy.

### UNIVERSITY OF CINCINNATI

There was a meeting of the University of Cincinnati Student Branch on February 24. The speaker of the evening, Prof. C. A. Joerger of the Mechanical Engineering Department, gave a paper on Present Day Problems and Tendencies. Professor Joerger called attention to the modern tendency to consider all men equal. The speaker held that this is a false ideal, and that men, rich and poor alike, should be judged by their inherent worth. Respect should be equal, but not the reward. It was pointed out that the tendency is to suppress individual initiative, and that this results in placing incompetent men in positions of responsibility. As corollary to the foregoing tendency, the speaker further emphasized the inclination to disregard experience and authority. His paper was received with great interest, and his conclusions met with general approval.

On February 25, Calvin W. Rice, Secretary of the Society, spoke to the student body on The Advantages of Membership in the Student Branch of the Society. Mr. Rice pointed out that the Society is of great help to engineering students, whether in the mechanical, electrical or civil department. He showed that through The Journal, the Society was furnishing at cost to the students a large body of data on all phases of engineering and was giving them the benefit gratuitously of research work carried on by the special staff of The Am. Soc. M. E.

Mr. Rice gave a lecture illustrated by stereopticon views on the visit of a delegation of the Society to the engineers of Germany. The German Government had one of their best engineers visit this country in advance of the date upon which the American delegation was to sail. This engineer after his return to Germany devoted his time and energy to preparation for the entertainment of the visitors. As a result, all arrangements for traveling, lodging, and sight seeing had been worked out to the smallest detail, and though all the principal cities and engineering works were visited, there was no hitch in the program and there were none of the numerous petty annoyances to which travelers are usually subjected. In every city, the visitors were received with great courtesy by the Mayor (always an engineer) and in many instances they were entertained by the highest officials. Everywhere the delegation was impressed with the remarkable efficiency of the German industrial organization.

### UNIVERSITY OF COLORADO

At the meeting of the Colorado Branch on February 25, a paper on Mechanics of Mining was presented by Frank E. Shepard of the Denver Engineering Works. He dealt with the process of mining from the mine to the smelter, taking up the machinery used and its development. With his experiences in the manufacture of mining machinery, he gave descriptions of the various types used for the different purposes. He said that an electric drill which used $1\frac{1}{4}$ h.p. had lately been developed, but that type of drive had not made the progress it should have made owing to the class of men called upon to handle it. The speaker showed that hoisting machinery is not a simple arrangement because of various attachments and combinations which introduce many complicated problems. The many ways of solving these questions were shown by means of sketches on the blackboard and were extremely interesting. The ore must be crushed in all sizes to free it from the gangue and make the mineral obtainable in a very finely powdered state. This crushing must be done in stages and many different kinds of crushers are in use. After crushing, the cyanide process is used to leach out many of the values. In some cases, the slime flotation method and in others the various types of concentration tables are used. The coöperation of all the branches of engineering are needed, thus requiring many men in one company to produce the results. Mr. Shepard further emphasized the importance of not discarding apparatus and machinery without a thorough trial under working conditions.

On March 11, Charles Hall of the Mine and Smelter Company, Denver, gave a short but interesting talk on Centrifugal and Triplex Pumps. He went into the conditions and arrangement of pumping machinery on different jobs, and mentioned the data needed in order to figure on various cases. Centrifugal pumps will carry about 30 per cent overload.

### UNIVERSITY OF KANSAS

A feature with the Student Section of the University of Kansas which is unique among all the student sections of The American Society of Mechanical Engineers is the plan of holding an annual meeting with morning and afternoon sessions, a dinner and speech making in the evening.

The sixth annual meeting was held on February 18 and was largely attended. A series of meritorious papers was presented, several of which it is hoped to publish in abstract in future numbers of The Journal. The morning and afternoon sessions were unusually interesting and contained papers as listed below. In the evening 125 attended the banquet. The papers presented were as follows:

The Relation of Technically Trained Men to the Industries, by Walter Rautenstrauch, professor of mechanical engineering at Columbia University, New York. This paper considered in detail some of the fields of service for the engineer and indicated what practice in these fields involved.

Internal Combustion Motors, especially the oil engine type, with special reference to the pumping service in the oil fields, by S. A. Sulentic, chief engineer of the Prairie Pipe Line Co., Independence, Kan.

Rate Making in Public Utilities, by Geo. C. Shaad. This paper dealt with the different types of service charges, including a consideration of intangible values and readiness-to-serve as elements in the problem.

Some Phases of Cement Manufacturing, by C. A. Swiggett, assistant superintendent of the Iola Portland Cement Co.

Manufacture of Gasoline from Natural Gas, by Louis Bendit, consulting engineer, Kansas City, Mo.

Heating and Ventilating Apparatus, by H. B. Kraft, of the Kansas City branch of the American Radiator Co.

The Results of Orifice Tests Conducted at Joplin, Mo., by Ernest O. Hickstein, engineer with the Wichita Natural Gas Co. This investigation dealt very fully with the conditions of air flowing through orifices and was an important investigation in the field of gas engineering. In conducting these tests, a gas holder of 250,000 cu. ft. capacity was used.

Service Equipment of the Harris Trust Building in Chicago, by I. W. Clark, student member.

Engineering Problems Arising in the Transportation of Natural Gas, by Jas. P. Fisher, chief engineer of the Wichita Natural Gas Co.

Prof. Walter Rautenstrauch of Columbia University, New York, who presented one of the papers, has kindly sent the following communication giving his impressions of this meeting:

"It was my pleasure to be the guest of the Student Branch of the A.S.M.E. of the University of Kansas at its Sixth Annual Meeting held Thursday, February 18, 1915, at Lawrence, Kansas. I was so favorably impressed with the work of this branch of the Society that I feel it would be well for each member of the Society to know how excellent a meeting of this sort may be. I, therefore, beg to submit to you an account of this meeting for publication in The Journal. The program which I enclose herewith contains a series of papers representing broad fields of activity of Mechanical Engineering and each one was presented in an interesting and instructive manner. The last two papers on the Flow of Air Through Orifices, by Mr. E. O. Hickstein, and Engineering Problems in the Transportation of Natural Gases, by Mr. James P. Fisher, were of a standard commensurate with those presented to the Society at its annual meetings. The students showed a real interest in each one of the papers presented and the whole meeting seemed to create a very deep impression on the minds of the students. The evening was devoted to a banquet at the principal hotel in Lawrence, at which about 125 members were present. A number of addresses were made at this banquet and a very pleasant evening was had by all those present. Great credit is due to Dean P. F. Walker for the manner in which he has conducted these annual meetings and it is believed that the work of this student branch may well be a model to all student branches throughout the country. It has occurred to me in this connection that a great benefit would result if there should be appointed a set day in the year to be known as the annual meetings of student sections of the A.S.M.E., at which time the whole day should be turned over to the presentation of papers such as is being done at the University of Kansas. It is felt that a definiteness would be given to the purpose of this work which would result in considerable benefit to the Society."

### UNIVERSITY OF KENTUCKY

A meeting of the Student Branch of the University of Kentucky was held February 18. P. L. Kaufman of the class of 1901, who is at present employed by the Bascule Bridge Company, gave an interesting talk demonstrated with numerous drawings on the principle and construction of the bascule-bridge. He also devoted a part of his time to a discussion of the aeroscope at the Panama Pacific Exposition. This instrument was invented by Mr. Strouss and a detailed discussion of it has lately appeared in Engineering News.

### UNIVERSITY OF MINNESOTA

A special meeting of the Minnesota Branch of the Society was held on February 25. Prof. S. C. Shipley of the Mechanical Engineering Department, University of Minnesota, gave a talk on Automobile Ignition Systems. He described first the early attempts at ignition by other means than the electric spark, and then the various modern ignition systems. The talk was illustrated by lantern slides. Because of the general interest of the subject to all engineers, the meeting was thrown open to all who cared to attend. There were forty-six people present.

In the Experimental Building on February 27, the Branch held a Get-together for all mechanical engineering students of the college and their friends. Prof. W. H. Kavanaugh, head of the Experimental Engineering Department, spoke of the history and achievements of the Am. Soc. M. E. Prof. J. V. Martenis, acting head of the Mechanical Engineering Department, gave an interesting description of a perpetual motion machine, about which his advice had been asked. J.

F. Colvin spoke of the purposes and aims of the Student Branch.

An open meeting of the Minnesota Branch was held March 4, in the Auditorium of the Main Engineering Building. Mr. Jackson of the Niagara Falls Carborundum Company gave a stereopticon lecture on the method and process of carborundum manufacture at the plant with which he is connected. He described in detail the power plant, the various departments of the manufacturing plant and their functions, and some of the many and varied uses to which carborundum products are put. The lecture was well attended.

#### UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch on February 18, I. O. Royse gave an interestiug and scientific lecture on the gyroscope. He commenced with the history of the gyroscope, its first users and early applications. He then explained the general laws of the gyroscope as they were formulated by Foucault, and how they were made use of by Schlick and Brennen. With the aid of lantern slides, he showed many present day applications, for example, mono-rail cars, gyro-compasses, two wheeled automobiles and stabilizers for ships. The gyroscope forms the essential parts of the steering apparatus of torpedoes. He also discussed the gyroscopic effect of the fly wheels of motor cars and aeroplanes.

At a meeting on March 4, Mr. F. A. Heileman gave a talk on the Heating System of the University. He first explained heating systems in general, including everything from a fire place to the modern steam system, and showed how the various principles were made use of in the local institution. Some of the many automatic devices for regulating the steam pressure, eliminating the air and removing water from the heating systems were described, together with the consequences of ignorant or careless handling.

#### WASHINGTON UNIVERSITY

The Student Branch at Washington University has been fortunate throughout the present school year in having heard lectures on a variety of engineering subjects by men who are known, some of them perhaps only locally and some far and wide among engineers.

Among the speakers were Earl B. Morgan, Safety Engineer for the Commonwealth Steel Company, who gave an illustrated talk on The Safety Movement in the Industry and its Relation to the Engineer.

H. R. Setz, Chief Engineer Oil Engine Dept. Fulton Iron Works, St. Louis, Mo., delivered an illustrated lecture on Some Phases in the Development of the Diesel Engine. He had drawings of Diesel's first experimental engines and gave a complete account of the early history of the engine, explaining the difficulties experienced in trying to make the Diesel cycle practicable.

Dr. M. Von Rechlinghausen whose system of water purification is much in use, even in the present European War, lectured before the Society on Ultra Violet Rays and their Application to Water Purification.

Dr. Thomas Watson, who assisted Graham Bell when he invented the telephone, gave a most interesting talk on his association with Graham Bell and the telephone.

#### WORCESTER POLYTECHNIC INSTITUTE

The Worcester Polytechnic Institute Branch held on February 19, a joint meeting with the Civil and Electrical Societies, to welcome home George H. Throop of the class of 1897, who addressed them on the subject of Public Utility Appraisals. Mr. Throop has been for some time with the J. G. White Company of New York City and was recently connected with the appraisal of the Pacific Gas and Electric Company's property, an immense system in California covering 40,000 square miles of territory. The speaker was in charge of the electric and street railway part of the work. His exposition of the various methods of figuring depreciation of plant and accessories was of particular interest to the seniors in the Mechanical Engineering course on account of the work in Shop Management. The lecture was illustrated with slides which showed the nature of the country, the power plants and transmission lines.

On March 5, there was an open meeting of the Branch. Invitations were extended to the members of the Worcester Automobile Club and their friends as well as to the general public. W. H. Weingar, representing the Maxwell Automobile Company, gave an interesting lecture on From Molten Metal to the Finished Automobile. The lecture was illustrated by several motion picture films, showing views of the factory and some outside points of interest.

## EMPLOYMENT BULLETIN

**Note: In sending applications stamps should be enclosed for forwarding.**

The Secretary considers it a special obligation and pleasant duty to be the medium of securing positions for members, and is pleased to receive requests both for positions and for men. The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period. Copy for the Bulletin must be in hand before the 18th of the month.

#### POSITIONS AVAILABLE

057 Company selling engineering specialties wishes services of technical man familiar with power transmission machinery and having $5000 to invest. Apply through Society.

059 Mechanical engineer and chief draftsman in the engineering department of a large industrial concern. Prefer man who has had several years experience in design of coal and ore handling apparatus and its application, ore and slag crushers, blast and zinc furnaces; steel, brick and wood buildings, bridge work and general steam and power plant engineering. Name confidential, apply by letter.

068 Man capable of taking charge of tool department in manufacture of sterling silver hollow ware; one who understands generally, machine shop practice, but more particularly familiar with up-to-date methods of working sheet metal, such as rolling, cupping, drawing and spinning; have charge of laying out the tools to manufacture the goods and supervise the making of the tools and their operation. Any knowledge of up-to-date methods of shop practice of advantage. Position has good future for the right man. Salary will depend entirely upon what experience the man has had in this or a similar line. Location New England.

069 Steam specialty salesman who desires to take on a line of vacuum heating specialties. Representatives wanted in all the leading cities. Apply through Society.

070 High class designer on automatic machinery wanted for concern in South.

071 Competent machine tool designer with manufacturing experience in the design and maintenance of machine tool equipment of factory, manufacturing work in large quantities, on interchangeability of part system. Desires man to take charge of drafting force; essential that he have ample machine shop experience and be familiar with jigs, fixtures, turret and automatic screw machines, machines, etc. Location New York State. Apply through Society.

072 Young man, aggressive and possessed of initiative, wanted as assistant professor of electrical engineering. Must be first of all a teacher, but have had some practical experience. Location, New England. Apply through Society.

078 Position as works manager, government dock yard at Newcastle, Australia. Salary 750 pounds sterling, three years engagement. Exceptional opportunity. First-class rail and steamer transportation allowed. Apply through Society.

079 Factory manager for plant located in Cleveland, making parts for automobiles and employing normally six hundred men. Applicant must have experience in heavy and

light manufacturing machinery for automatic production, heat treating methods of metals, efficiency methods as to production and cost, and must be capable of handling men. State age, references and salary desired, or present salary. Apply through Society.

080 Opportunity desired for investment by man interested in engineering projects, who wishes to be associated in an established, "going concern" in construction or manufacturing enterprise where financial assistance would assure a managerial position. In position to secure investment interests of other parties. Name confidential. Apply through Society.

082 General superintendent to take full charge of works manufacturing cartridges. Name confidential. Apply through Society.

MEN AVAILABLE

D-41 Technical executive, mechanical engineer, young man, experienced in design and construction of special machinery, maintenance of property and engineering, construction and operation of power plants and buildings, high voltage transmission, etc. Past five years superintendent of plant department employing 225 men, desires to make change, with better opportunities. Present salary $4000 per year.

D-42 Associate-member, M.I.T. graduate, age 27, five years experience teaching, in factory and laboratory, desires to work through each department of factory with object of becoming assistant superintendent.

D-43 Graduate mechanical engineer, age 27, has worked as apprentice, in machine shop, draftsman, estimator and outside trouble man for large manufacturing concern, also efficiency man in food producing concern, desires position combining inside and outside work or as testing engineer.

D-44 Junior member, graduate mechanical engineer with post graduate course in hydraulic and water power engineering at M.I.T., employed for the past year in the State of Washington on hydrographic survey and river improvement work, desires position with company in hydraulic construction work. Location preferred western states.

D-45 Member, graduate mechanical engineer, University of Pennsylvania, eleven years experience in design and erection of hydraulic riveters and presses, steam hammers, steel mill machinery and elevator safeties, desires position as engineer or chief draftsman.

D-46 Member, expert on machine shop practice and modern tools, successful experience as superintendent of large shop, and sales manager of well known machine builders, would like to represent responsible concern in New York or Philadelphia. Salary or salary and commission.

D-47 Junior, age 26, unmarried, two years experience in cost and efficiency work, capable of producing results, desires position with firm contemplating installing efficiency methods for cost systems.

D-48 Member, graduate mechanical engineer, 20 years experience as designer and chief draftsman with leading manufacturers of simplex and duplex steam pumps, desires position.

D-49 Junior, technical graduate, experienced in hydraulics, steam, gas and oil engineering, three years in the tropics, sales work, general mechanical installation and operation, desires permanent connection with reliable firm.

D-50 Member, A.S.M.E. and S.A.E., age 37, thorough practical experience designing manufactured articles, laying out plants, designing and building special equipment and tools, inaugurating economical production and clerical systems, producing results, desires position offering a wider field than possible with present employers.

D-51 Junior, graduate M.E., who will very shortly complete a special apprenticeship with one of the largest railroad systems, desires position where this training will be of immediate value. Location immaterial.

D-52 Member, age 32, married, 15 years practical and executive experience in machine tool, automobile and gear manufacturing with representative concerns, now employed as superintendent, desires position along similar lines, or would take an interest in small firm having meritorious line to manufacture. Replies treated confidentially.

D-53 Junior, graduate M.E., four years experience in manufacturing and designing, desires similar position or along commercial line. At present in assistant executive position.

D-54 Junior, technical graduate in mechanical and electrical engineering, 12 years varied experience in design, construction, operation and maintenance of power houses and sub-stations; familiar with up-to-date methods of mapping and execution of construction and repair orders in power plant and mill accessories, experienced in testing and experimental work, possessing executive ability and pleasing personality, desires position of power engineer, assistant superintendent, assistant manager or works manager. At present employed. Location preferred, New York or vicinity.

D-55 Student member, age 23, graduating in June 1915 from Stevens Institute of Technology, experienced as draftsman, mechanic's helper on erection work, inspector of gas and water supplies, automobile repairs, and general office work in connection with railway association, desires any position which offers opportunity for advancement.

D-56 Engineer, with broad designing experience on metal working machinery and tools, is open for position. Can offer an improved design of machine in several sizes for a company wishing to extend their line. Location, middle West preferred.

D-57 Member, technical graduate, wide training and experience in design of power plants and machinery, construction, maintenance and operation, purchasing engineering material, executive charge of all consulting engineering work, including building construction of all kinds, desires position as works manager or superintendent.

D-58 Junior member, age 28, graduate mechanical engineer, five years practical experience, last two and one half years engineer of tests of large automobile company, desires position as assistant superintendent or engineer.

D-59 Mechanical engineer, Lehigh graduate 1912, three years experience in maintenance and equipment work, desires position. At present employed.

D-60 Member, age 35, technical graduate, married, 12 years experience in design, operation and construction of steam electric plants and purchasing equipment; specialist in fuel economy and fuels, desires position as mechanical or power plant efficiency engineer with company operating steam plant or chain of plants of large capacity in which better operating economy is desired. At present employed, but seeks position with chance for advancement.

D-61 Junior member, age 29, mechanical and electrical engineer, 12 years experience in design, construction, operation and maintenance of power plants of public utility and industrial corporations, having held positions as superintendent and chief engineer, and in charge of complete power tests, desires position with consulting engineer or large engineering corporation, or as power engineer for industrial corporation. Location immaterial.

D-62 Member, at present employed, but desiring greater opportunity, would consider position in engineering or designing department of concern requiring the services of a practical man with experience in elevator work. Location preferred, Eastern states.

D-63 Member with wide practical experience, fully acquainted with machine tool market, domestic and foreign,

travelled here and abroad, would like to represent first class firm in eastern territory; will travel if necessary. At present holding position as sales manager.

D-64 Member, engineering graduate, 14 years practical experience, four years as instructor in mechanical engineering, would consider position in well known engineering school or college. At present employed.

D-65 Associate-member, engineering graduate, six years teaching and four years general engineering experience, desires position for the coming academic year in mechanical department of a technical school.

D-66 Member, age 36, graduate M. E. of M. I. T., whose present position and previous work has required initiative, executive ability, tact, organization of men and the direction of their efforts along business lines as well as engineering. Experience also includes buying, selling, manufacture and construction work; familiar with office management, costs, keeping proper records and handling correspondence.

D-67 Associate member engaged at present in engineering sales line desires position as salesman or assistant sales manager.

D-68 Member, also Member Institution of Mechanical Engineers, for 16 years with exporters and importers of machinery, in charge of technical department in London and Tokyo, with wide experience in all technical and commercial work and in the American, European and Japanese markets; English, German, French correspondence, also some Spanish, requires responsible situation in similar capacity.

D-69 Junior, post-graduate M. E., Purdue University, age 31, nine years engineering experience in industrial management, has served successfully as special machine shop and foundry apprentice, staff engineer with production engineers of national reputation, superintendent of manufacturing; for last five years works manager, construction engineer on new works and equipment and plant manager for large manufacturers of mechanical goods and plated ware, desires position where experience would be of value. Available June first.

D-70 Mechanical engineer, age 33, with broad experience in the design and construction of water tube boilers, desires position in similar capacity, or as chief engineer or sales engineer.

D-71 Member, age 38, 16 years experience in mechanical, and structural work of great variety. Expert on economical and unique arrangements for handling coal, ore, ash and other materials; experience in economical plant lay outs and mill building design, wishes position with consulting, contracting engineer or industrial plant. Will take position at reduced salary till ability is proven.

## ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Boiler Manufacturers Association of the United States and Canada. Proceedings of 25th Annual Convention. 1913.

American Standard for Pipe Flanges, Fittings and Bolting for Same. *New York, American Society of Mechanical Engineers, 1914.*

Die Arbeiten und Erfindungen Faber du Faurs auf dem Gebiete der Winderhitzung und der Gasfeuerung, by Eduard Herzog. *Halle a. S., 1914.*

Beihefte zum Gesundheits Ingenieur. Band I, pt. 4, 5. *München, 1914.*

Brown University. Historical Catalogue, 1764-1904. *Providence, R. I., 1905.*

Carnegie Endowment for International Peace. Signatures, ratifications, adhesions and reservations to the conventions and declarations of the first and second Hague peace conferences. (Pamphlet no. 3) *Washington, 1914.* Gift of Carnegie Endowment for International Peace.

Carnegie Institution of Washington. Year Book, 1914. *Washington, 1914.* Gift of Institution.

Cement Stucco. Bulletin no. 22, Association of American Portland Cement Manufacturers. *Philadelphia.* Gift of Association.

Central Power Station Rates. Legal opinion of Louis D. Brandeis. Gift of Uniform Electric Rate Association.

Chicago. Department of Public Works. Bureau of Engineering. Report Official Duty Test of Booster Pumps, Roseland Pumping Station, Chicago, Ill. *Chicago, 1914.* Gift of John Ericson.

Concrete Septic Tanks. Gift of Association of American Portland Cement Manufacturers.

Concrete Tanks. Association of American Portland Cement Manufacturers. Bulletin no. 23. *Philadelphia.* Gift of Association.

Cotton Warehouses and Terminal of the State of Louisiana. Built and operated by the Board of Commissioners of the Port of New Orleans. Gift of Ford, Bacon & Davis.

Edison Phonograph Works, Report on fire, Dec. 9, 1914. Gift of Ira H. Woolson.

Electric Rates. An Analysis of Elements Entering into Cost of Service, P. R. Moses. Gift of Uniform Electric Rate Association.

Elements of Hydraulics, S. E. Slocum. *New York, 1915.*

Federal Valuation of Railroad Property, R. J. McCarty. *Kansas City, 1915.* Gift of author.

Heating and Ventilating Buildings, Rolla C. Carpenter. Ed. 6. *New York, John Wiley & Sons, 1915.* Gift of Publishers.

This edition has been largely rewritten and considerable new matter added. This edition brings the total issue up to twenty thousand. Especial attention is directed to the chapter on air-conditioning, summarizing recent papers on the subject before this society. W. P. C.

Die Kessel und Maschinenbaumaterialien, Otto Hönigsberg, *Berlin, 1914.*

Kühlmaschinen und Kühleinrichtungen für Kriegs-und Handelsschiffe, Eduard Reif. *Wittenberg, 1912.*

Leitfaden für den Unterricht in Eisenkonstruktionen an Maschinenbauschulen, L. Geusen, *Berlin, 1915.*

Minute Adopted by the Research Corporation in Recognition of the Service Rendered by Frederick G. Cottrell to the Advancement of Science. Jan. 15, 1915. Gift of C. W. Rice.

Motoren für Flugzeuge und Luftschiffe, Fritz Huth.. *Berlin, 1914.*

National Marine Engineers' Beneficial Association. Journal of Proceedings. vol. XIII, no. 2. *Washington, 1915.*

National Tubular Boiler Makers' Association, American Society of Mechanical Engineers and American Association of Steel Manufacturers. Minutes of Joint Meeting of Committee, June 15, 1914.

New York City. Board of Estimate and Apportionment. Monthly bulletin of tests made in laboratories conducted by the City of New York upon samples taken from deliveries of materials and supplies to City Departments. *November 1914.* Gift of Board of Estimate and Apportionment.

Oberflächenverbrennung und "Flammenlose" Feuerungen, Ed. Donath. *Halle a. S., 1914.*

One Hundred Fifty Years of Road Building in America, N. C. Rockwood. *New York, 1914.*

Practical Irrigation and Pumping, B. P. Fleming. *New York, 1915.*

Reinforced Concrete Chimneys. Bulletin no. 18, Association of American Portland Cement Manufacturers. *Philadelphia, 1910.* Gift of Association.

Reinforced Concrete Poles. Bulletin no. 25. Association of American Portland Cement Manufacturers. *Philadelphia.* Gift of Association.

Sociological Engineering, Economics and the Mastery of Materials. J. S. Warner. University College, London, Engineering Society, Nov. 26, 1914.

Southern and Southwestern Railway Club. Proceedings, Nov. 1895. Gift of Railroad Branch Young Men's Christian Association.

Sperry Gyro-Compass and Navigation Equipment. Ed. 2. *New York, 1912.* Gift of Elmer A. Sperry.

Steam Boiler Explosions. W. H. Boehm. Lecture delivered at Cornell University, May 3, 1912.

Die Stellung der deutschen Maschinenindustrie im deutschen Wirtschaftsleben und auf dem Weltmarkte. Fr. Frölich. *Berlin, 1914.*

Die Turbinen für Wasserkraftbetrieb. A. Pfarr. Ed. 2. Text and Atlas. *Berlin, 1912.*

Uniform Standard Specifications, Minutes of Meeting, Sept. 20, 1914.

Utilization of Solar Energy. A. S. E. Ackermann. Reprinted from Transactions of Society of Engineers, 1914. Gift of author.

George Westinghouse, 1846-1914. Biography. Arthur Warren. Gift of Arthur Warren.

GIFT OF AERONAUTICAL SOCIETY

Aero. vol. 2, nos. 21, 23, 24; vol. 3, no. 20; vol. 4, no. 18; vol. 6, no. 3. *St. Louis, 1911-13.*

Aero Club of America. Bulletin, vol. 1, nos. 1, 3-4, 6-7; vol. 2, nos. 1-4, 6-11; vol. 3, no. 3. *New York, 1912-14.*

Aeronautics. vol. 5, no. 51, May 1912.

Automobile Journal. vol. 32, nos. 1-3, 6. *Pawtucket, R. I., 1911.*

Flight. vol. 6, no. 161, Jan. 27, 1912.

Fly. vol. 1, no. 1-3. *Philadelphia, 1908-09.*

Handbook on Automobile Electric Systems. 1913.

L'Institut Aérodynamique de Koutchino. Bulletin. Fascicule II-IV. *Moscou, 1909, 1912.*

GIFT OF BUREAU OF RAILWAY ECONOMICS

The Deadly Toll of Trespass on Railways. Railway Business Association Bulletin no. 16. *Jan. 27, 1915.*

Some Political Phases of Government Ownership. Samuel O. Dunn. Reprinted from The Atlantic Monthly, Feb. 1915.

Fred Warren. A Problem for Two Nations. Address to the Alumni Association of the Massachusetts Institute of Technology, Howard Elliott, Boston, Jan. 9, 1915.

GIFT OF JOHN PHILP

The library of the late Horace See, former President of the Society. The collection is particularly strong in sets of periodicals and works on naval architecture. This is one of the most important additions to the Library made in recent years.

EXCHANGES

American Railway Engineering and Maintenance of Way Association. Proceedings. vol. 11, pts. 1-2; vol. 12, pts. 1-3; vol. 13. *v. p. 1910-12.*

American Railway Master Mechanics' Association. Report of the Proceedings of the 47th Annual Convention, Part I-II. *Chicago, 1914.*

Institution of Civil Engineers. Minutes of Proceedings, vol. 197. *London, 1914.*

University of Illinois. Engineering Experiment Station. Bulletin, volume X, 1913-14. *Urbana, 1914.*

TRADE CATALOGUES

Fafnir Bearing Co. *New Britain, Conn.* Catalog no. 15. Ball bearings. 44 pp.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. Feb. 1915.

Leschen, A., & Sons Rope Co. *St. Louis, Mo.* Leschen's Hercules. Feb. 1915.

Norton Company. *Worcester, Mass.* Cam Grinding and cam grinding equipment. 23 pp.

Henri Priol. *Paris, France.* Benne Preneuse automatique "Temperley."

Pacific Flush-Tank Co. *Chicago-New York.* Catalog no. 17. Automatic Sewage Ejectors. 1914.

Terry Steam Turbine Co. *Hartford, Conn.* Bulletin no. 19. Centrifugal pumps. Oct. 1914.

Textile Machine Works. *Reading, Pa.* Full fashioned knitting. An American industry.

Under-Feed Stoker Co. of America. *Chicago, Ill.*, Publicity magazine. Jan. 1915, Feb. 1915.

Valley Iron Works Co. *Appleton, Wis.* The Beater. Jan. 1915.

Youngstown Sheet & Tube Co. *Youngstown, Ohio.* Quality pipe. 43 pp., 1914.



[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal

# Important Articles in the Journal

## CONTRIBUTED BY LOCAL SECTIONS, 1914-1915

ASIDE from the Spring and Annual Meetings of the Society, local meetings are now being held in 14 cities throughout the country. These local meetings bring a large amount of valuable information to the membership through the columns of The Journal. Among the articles which have appeared or which are to appear during the present fiscal year, are the following:

Brake Performance on Modern Steam Railroad Passenger Trains, S. W. Dudley, November, 1914.

Recent Developments in the Manufacture of the Diesel Engine, H. R. Setz, December, 1914.

Panic Economies and Emergency Problems with Especial Reference to the Present Industrial Situation, F. A. Waldron, December, 1914.

Spaulding-Drum Power Development, John A. Britton, April, 1915.

Recent Developments in Steam-Electric Generating Stations, John Hunter, April, 1915

Gas Producers with By-Product Recovery, Arthur H. Lymn, May, 1915

Modern Steels and Their Heat Treatment, Robert R. Abbott, May, 1915.

A Proposed System of Classifying and Digesting the Records of the Society, Edwin J. Prindle, May, 1915.

Boston Symposium on Employment and Education, Walter C. Fish, William B. Hunter, Prof. Thomas N. Carver and Henry S. Dennison, May, 1915.

Refrigeration with special reference to Ice Making as a By-Product of Central Stations, Heywood Cochrane (in preparation).

Application of Engineering Methods to the Problems of the Executive, Director and Trustee, Dr. Hollis Godfrey (in preparation).

Modern Electric Elevators and Elevator Problems, David Linquist (in preparation).

A Novel Method of Handling Boilers to Prevent Corrosion and Scale, Allen H. Babcock (in preparation).

Engine-Driven *vs.* Turbine-Driven Units in Small Capacities, A. C. Wood (in preparation).

Diesel Engines and Their Application to Southern California, Prof. Walter H. Adams (in preparation).

Interesting Features in Design of Connors Creek Plant of Detroit Edison Co., Prof. C. F. Hirshfeld (in preparation).

Engineering Problems Arising in the Transportation of Natural Gas, Jas. P. Fisher (in preparation)

The variety of topics treated in these meetings is indicated in the following classification:

| | | | | | |
|---|---|---|---|---|---|
| Power Plant | 5 | meetings | Elevators | 1 | meeting |
| Industrial Management | 3 | " | Metals and Metallurgy | 1 | " |
| Gas Power | 3 | " | Refrigeration and Ice-Making | 1 | " |
| Railroad Equipment | 1 | " | Classifying and Indexing Technical Matter | 1 | " |
| Gas Engineering | 1 | " | | | |

This emphasizes the importance of the local meetings as factors in the development of the usefulness of the Society and of The Journal. They are of direct benefit to members in different localities in not only extending the advantages of the technical meetings, but also by developing a large amount of original engineering data that would not otherwise be accessible. The hearty coöperation of the membership is urged in this development.

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 — MAY 1915 — Number 5


## CONTENTS

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C 55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.


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## COMING MEETINGS OF THE SOCIETY

*May* 11, *New York*. Subject: Metal Spray Processes in Engineering and Art, by John Calder.

*May* 14, *Chicago, Ill.* Subject: Electric Locomotives, by A. H. Armstrong, Assistant Engineer, Railway and Traction Department, General Electric Company.

*May* 19, *St. Louis, Mo.* A joint paper by several of the heads of departments at Washington University on Duration and Contents of an Engineering Course of Study.

*June* 9, *St. Louis, Mo.* Subject: Needed Improvements in Specifications, by J. B. Emerson.

Spring Meeting, Buffalo, N. Y., June 22-25. See page V.

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 May 1915 Number 5


## THE SPRING MEETING

THE SPRING MEETING, to be held at Buffalo June 22 to 25, is the first general meeting of the Society to occur in this city, although there has been one meeting at Niagara Falls. While Buffalo is a beautiful city, always attractive to visitors and of particular interest to engineers because of its diversified manufacturing, part of one day will be spent at Niagara Falls so that all may have an opportunity to enjoy as well the many attractions of this point of national interest. The month of June is the finest time of the year in which to visit this section of the country and the outdoor surroundings of Buffalo and the beautiful Federal Reservation at Niagara Falls will be at their best.

The arrangements for the entertainment of the Society are in the hands of a large local committee of which David Bell is Chairman, James W. Gibney, Vice-Chairman, C. A. Booth, Secretary, and C. H. Bierbaum, Treasurer. The Engineering Society of Buffalo is to join with our own members and with engineers generally in the city as hosts of the occasion.

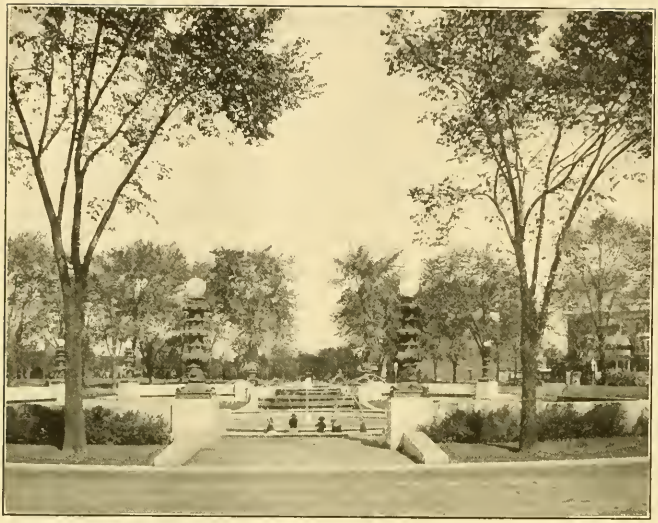
The headquarters during the meeting will be at the Hotel Statler, where most of the sessions and entertainment features will be held. As usual, registration will begin on Tuesday (June 22) and on Tuesday evening there will be an informal reception with an address of welcome by Mayor Louis Fuhrmann of Buffalo. A welcome will also be extended on behalf of the manufacturing interests of the city. Dr. John A. Brashear, President of the Society, will respond, after which the evening will be spent informally and a buffet luncheon will be served.

On Wednesday morning, bright and early, the party is to be conducted to Niagara Falls in time to hold the opening session there, including the business meeting, for which purpose the large auditorium of the Shredded Wheat Biscuit Company has been offered. It is customary at Spring Meetings for local engineers to provide papers for one session, and these papers for the Buffalo meeting will be read at the Wednesday morning session. During the session the ladies of the party will have an opportunity to inspect the Shredded Wheat factory and the plant of the Falls Chocolate Company, both of exceptional interest.

The afternoon will be available for the enjoyment of the beauties and grandeur of Niagara Falls or for visiting any of the industries that have grouped themselves in this city of 50,000 population. Unfortunately, a large number of these plants consider their operations in the nature of secret processes and visitors, especially technical visitors, are not granted admittance. However, some of the factories and the various power stations will be open for inspection. There will be time for those who desire to do so to take the trip of the Gorge Route.

The return to Buffalo will be in time for the lecture on Wednesday evening to be given by Dr. F. H. Newell, formerly Chief of the U. S. Reclamation Service, who has recently spoken so acceptably at several meetings of engineers in different cities and before student sections of the Society. The address will be on The Engineer as a Citizen and will be a presentation of the duties and standing of the engineer in his relation to the public. It will be illustrated by a remarkably fine collection of colored lantern slides illustrating the important work which the government has done in reclaiming the great areas of arid land in the West.

On Thursday morning there will be two simultaneous sessions for the discussion of papers, and the afternoon will be free for visiting the manufacturing plants in Buffalo. On this afternoon, special entertainment is to be provided for the ladies in the way of an automobile ride, with tea served either at the Country Club or the Automobile Club. During the ride there will be opportunity for visiting points of interest, such as the Roycroft Shops at East Aurora, where the Roycrofters engage in the arts of bookmaking, printing, the making of craftsman furniture and various ornamental products. Ladies desiring to visit the Larkin factory also may do so.



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Gates Circle, Buffalo

be left free for inspection trips.

A list of the papers which have already been selected by the Committee on Meetings for presentation at the Spring Meeting with a summary of their contents is given elsewhere in this number. These papers are of a high order of merit and are miscellaneous in character, treating of a variety of subjects. They will be printed in pamphlet form well in advance and will be distributed at the meeting as usual. Any members who desire copies in advance may obtain them upon *application to the Secretary.*

A brief summary of the industries of Buffalo and vicinity and of features of interest both at Buffalo and Niagara Falls are given below, and members and their friends will be cordially welcomed at any of these places.

On Thursday evening, the usual dance and reception, which is one of the features of the Spring Meeting and always a delightful occasion, will be held at the Hotel Statler.

On Friday morning the final professional session of the meeting will be held, and the afternoon again will

## BUFFALO AND NIAGARA FALLS AND THEIR INDUSTRIES

### THE ENGINEERING SOCIETY OF BUFFALO

Of first interest to visiting engineers will be the Engineering Society of Buffalo which, with local members of The American Society of Mechanical Engineers, has extended

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The Whirlpool Rapids, Niagara Falls

MEMBERS AND GUESTS ARE INVITED TO SPEND WEDNESDAY OF THE SPRING MEETING AT NIAGARA FALLS

PLANT OF LACKAWANNA STEEL COMPANY, BUFFALO

the cordial invitation to visit Buffalo. The Buffalo Society was formed only three years ago but already has 320 members, of which 50 are members of the Am. Soc. M. E. While an independent body, it feels that it owes a large measure of loyalty to the national Society and does all in its power to encourage the local members to join. It is broadly representative of all engineering activities, including in its membership civil, electrical, and mining engineers, chemists and architects. Meetings are held every two weeks.

### BUFFALO FOUNDRY AND MACHINE COMPANY

This plant has a capacity in its cupolas for melting 55 tons per hour and many castings up to and over 100 tons weight are made, and besides there is ample equipment for machining large pieces. One of the specialties is the production of vacuum apparatus for all purposes, including small laboratory experimental devices and machines with a volumetric capacity as great as 5 ft. in diameter by 12 ft. long. Over 60 years ago David Bell, Sr., evolved his first designs of steam hammers which have since been another specialty of this company and are built in sizes up to 200 tons in weight.

### THE LACKAWANNA STEEL COMPANY

This is generally considered to be the largest independent steel producing plant in the world. It covers approximately 1500 acres along the shore of Lake Erie, near Buffalo, and gives employment to about 12,000 men. The annual payroll expenditure is over $10,-500,000 and the gross production about 1,250,000 tons.

Of interest to the members of the Society will be the Lackawanna deseaming process for rails which formed the subject of a paper at the last annual meeting by Robert W. Hunt of Chicago, Ill. Visitors should also see the new W-9 Merchant Mill which is the latest word in planning and construction. This design has been the result of extensive study of other mills at home and abroad. One interesting feature that always strikes the visitor is the "Safety Arch." It will be noticed in the photograph on page IX that there are tags extending on each side of the frame. These bear the names of the different departments and when all is well, a small metal American flag flies alongside each, but if an accident has happened during the preceding 24 hours, the flag is covered with a black sleeve. Great interest is taken by the men in keeping their flags flying and this arch has been of decided value in reducing the number of accidents.

### LARKIN COMPANY

In 1878, the Larkin Company conceived the idea of selling directly from factory to ultimate consumer. The idea prospered and from a small beginning in a factory having an area of 3000 sq. ft. their business has grown until today it is housed in a plant containing some 40 acres of floor space. This immense factory is devoted to the production



SHELTON SQUARE, BUFFALO

of soaps, perfumes, kitchen necessities and the staple groceries such as tea, coffee, sugar and spices.

The office building where the large and extremely complicated affairs of the Company are conducted typifies the last word in office system. Particular attention has been paid to lighting by direct daylight during the day and by indirect illumination during the evening. Phonograph dictation is used. Desks and chairs are all designed so that they take up the least possible floor space and allow for maximum cleanliness. Chairs swing under the desks when not in use, thus leaving the aisles practically clear. Much of the furniture is of pressed steel in a special design.

This careful attention to detail is followed throughout the factory. One of the most interesting things to visitors is the system whereby Larkin products are distributed to all parts of the country. The shop floors are divided into sections, each named for a State in the Union. Box cars are taken on large elevators and lifted up to the floor which is named for the State that is their ultimate destination. Here the car is completely loaded, thus avoiding excessive handling and damage by trans-shipment.

#### THE WICKWIRE STEEL COMPANY

The Wickwire Steel Company operates a small but very high quality blast furnace plant within a very short distance of Buffalo. Their plant is very modern, having been erected in 1910. The output is in the neighborhood of 350,000 tons of iron a year. The company owns its ore properties, and also a fleet of large lake carriers for transporting the ore to the plant. They make a special point of producing special analyses of iron, and their methods of handling raw material to insure that the analysis shall be as specified will prove of much interest to visitors.

#### PRATT AND LAMBERT COMPANY

The Pratt and Lambert Company is one of the world's largest varnish manufacturers, and their plant in Buffalo offers much that is of interest. Their "Vitralite" white enamel, which can be brushed within a short time after its application, is of particular interest to engineers, and the company extends a cordial welcome to visitors. This company is one of the largest national advertisers, and maintains a complete printing equipment capable of handling not only the ordinary run of work but elaborate color printing as well.

#### SNOW STEAM PUMP WORKS

This is one of the plants of the International Steam Pump Company, and was originally established in 1889. Since then it has enlarged to many times its original capacity. The Indianapolis pumping station built in 1895 was equipped with what was, at that time, the largest pumping engine in the world, built by this company. In 1900 this concern took up the manufacture of gas engines, concentrating attention on the largest sizes only. The total horsepower of the gas engines built by them up to 1914 was 211,000.

Prior to the expiration of the Diesel patents, this company had been investigating oil engines and in 1912 they began to produce two- and four-cycle Diesel oil engines, both of the horizontal and vertical type. These are also made chiefly in the largest sizes and their design represents the latest developments of this work in the United States.

A visit to the Snow Steam Pump Works should certainly be taken by those interested and a cordial invitation is extended.

#### PIERCE-ARROW MOTOR CAR COMPANY

The Society is invited to make the works of this company one of the points of interest to be visited. This is considered to be one of the most up-to-date factories of the type in the country and its product is confined strictly to high grade automobiles and motor trucks. It has an area over 1,000,000 sq. ft. The ideals of the company are high and engineers will be impressed with the methods used to insure that the materials employed are up to specifications. Forgings and castings, although coming in in large quantities, are all carefully inspected and tested with the scleroscope or Brownell machine to ascertain that the heat treatments have been properly carried out. In addition, a laboratory and metallurgical department are maintained for research into the latest developments and uses of materials. The company does not do its own forging or foundry work, but has large machine shops, firing rooms and assembling departments.

The product consists of pleasure cars in three models, 38, 48 and 66 h.p. and also two capacities of motor trucks, 2-ton and 5-ton, equipped with special devices for handling all kinds of loads. These trucks will be of especial interest to engineering contractors, by whom they are largely used.

The Pierce-Arrow Company is also noted for its welfare work, and those interested in this line of endeavor should not miss the opportunity of seeing their large kitchen and dining hall and other conveniences that have been provided for the use of the employees. Altogether some 4000 men are employed.

#### SOME BUFFALO FOUNDRIES

To those interested in foundry work, the plant of the Pratt and Letchworth Company will well repay a visit. This is an exceedingly large foundry, specializing in freight car and locomotive castings in malleable iron and steel. The plant, although an old one, is constantly being brought up to date.

Other foundries are the Bingham and Taylor Company, also a large company, which is just now developing a process for making small steel castings.

The Aluminum Castings Company has a large plant devoted to the production of very large but thin aluminum castings.

The D. W. Sowers Manufacturing Company specialize in the casting of small, high grade cylinders for gas and oil engines. Their product is being used by the Curtis Aeroplane Company.

#### THE BUFFALO FORGE COMPANY

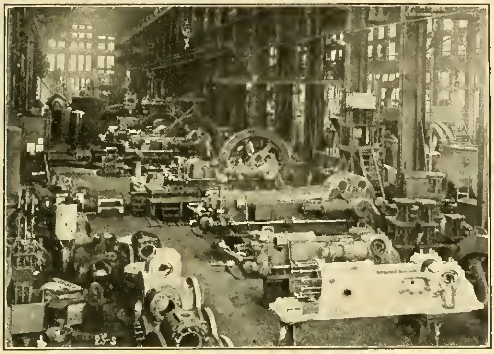
This is one of Buffalo's largest industries. The company specializes in the manufacture of ventilating and drying apparatus under the Carrier patents. Mr. W. H. Carrier, member Am. Soc. M. E., has installed his humidifiers in many varied industries and it is stated that his system has greatly facilitated the manufacture of cotton and woolen goods in this country.

#### THE SIMONDS MANUFACTURING COMPANY

Lockport is a small city some 25 miles from Buffalo and

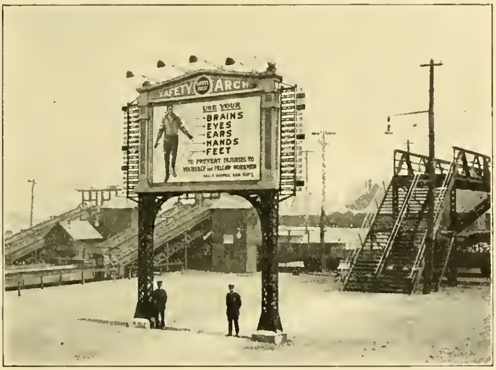
is easily reached by trolley car. The Simonds Manufacturing Company located there, manufactures saws, files and steels and have a large plant which is well worth a visit. The location is near enough to the Falls to make electric power easily available, and this company is now installing a large electric furnace for the production of a very high grade of tool steel. There are many special features in connection with this, such as the use of fluid compression in the manufacture of high grade armor plate in conjunction, of course, with the Simonds Company's well known quality of tools, and a visit to the plant will be of interest.

While in Lockport the visitor should not miss the opportunity of inspecting the immense locks on the barge canal which connects Lake Erie with the Hudson River.

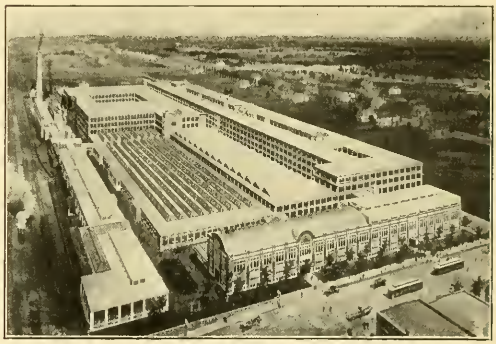


Erecting Shop—Snow Steam Pump Works

Plate Mill—Lackawanna Steel Company

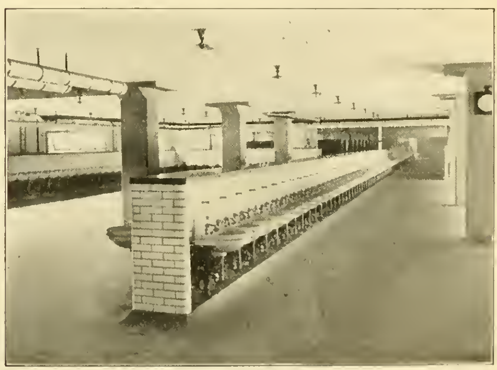



Safety Arch—Lackawanna Steel Company



View of Plant—Pierce Arrow Motor Car Company

Dining Hall—Pierce Arrow Motor Car Company



Model Lavatory—Pierce Arrow Motor Car Company

MEMBERS ARE CORDIALLY INVITED TO VISIT THE INDUSTRIAL PLANTS OF BUFFALO

###### THE ROYCROFT SHOPS

Another place in the vicinity of interest especially to the visiting ladies, is East Aurora, a beautiful country town only 18 miles from Buffalo, the home of Elbert Hubbard and the Roycroft Shops. The Roycrofters form a community operating their own hotel, or rather inn, and their own farm. Mr. Hubbard has advanced ideas on the responsibility of the employer towards his work and workmen which he attempts to carry out in all sincerity. This institution is unique in the United States and never fails to interest visitors and to provide them with considerable food for thought.

###### IN GENERAL

There are so many varied industries in Buffalo that it is impossible to mention all of them, but visitors have only to make known the factories they wish to visit and the committee of the Buffalo Engineering Society, which is looking after this matter, will do their best to enable them to visit the plants in which they are specially interested.

###### NIAGARA FALLS

Of first interest from an engineering standpoint at Niagara Falls are the power plants and here are located also the many electro-chemical industries, which, however, in general, are not open to the public. One-half million electric horse power are being generated and supplied at low cost to districts as far as 250 miles distant. This is the home of the Shredded Wheat Biscuit Company, famous throughout the country because of its model factory, a favorite place for visitors and a meeting place for societies holding conventions at Niagara Falls. The plant of the Falls Chocolate Company is also of interest.

At this time of the year the natural attractions of Niagara Falls, the Park and Goat Island constituting the Government Reservation, the beautiful foliage, the wooded slopes extending down to the rapidly rushing waters in the Gorge will be at their best. The Gorge trip, extending on both sides of the Gorge and on the American side, practically at the water's edge, is always an attraction of interest.

# ABSTRACTS OF PAPERS TO BE PRESENTED AT THE SPRING MEETING

## LAPS AND LAPPING

By W. A. Knight and A. A. Case

This paper gives details of tests of abrasives when used for lapping operations with the object of determining the effect on the rate of cutting with different combinations of abrasive, lubricant, and lap material. The tests were made with hardened steel specimens, on a machine built especially for the purpose.

Comparative results were obtained with emery, alundum, and carborundum used in connection with lard oil, machine oil, gasoline, kerosene, turpentine, alcohol, and soda water. The lap materials were cast iron, soft steel, and copper.

The investigation shows that in general there is a lubricant that will give best results with a given combination of abrasive and lap. Thus, emery on the cast lap gives best results with gasoline and kerosene, while lard oil and machine oil are distinctly inferior. On the other hand, with carborundum on the steel and copper laps, lard oil and machine oil do the best work of any of the lubricants tested, while gasoline and kerosene do the least efficient work with these combinations. Lard oil invariably gives a higher rate of cutting than machine oil.

Carborundum usually gives a higher rate of cutting than the other abrasives, but it also wears the lap faster. The tests show that carborundum wears the lap surface about twice as fast in proportion to the amount ground from the steel specimen as does emery, and the wear with alundum is one and one-fourth times that with emery. Also, the wear of the copper lap is about three times, and the steel one and one-fourth times, that of the cast iron. This wear is shown to be inversely proportional to the hardness of the lapping plates, as shown by the Brinell test.

Comparisons were made, too, between the "wet" and the "dry" methods of lapping. In dry lapping much depends on the manner of charging the lap. Results show that with the wet method the rate of cutting is two to six times as fast as with the dry, depending on how the lap was charged.

## MODEL EXPERIMENTS AND THE FORMS OF EMPIRICAL EQUATIONS

By E. Buckingham

The object of this paper is to illustrate the use of the dimensional method of reasoning in devising empirical equations and in planning and interpreting experiments,—particularly experiments on models.

After stating the principle of the method in the form of a convenient theorem application is made to the familiar problem of flow through smooth pipes so as to illustrate the working of theorem in a well known case. The next application is to the resistance of totally immersed bodies such as submarines: it leads to the notion of dynamical similarity and the interpretation of experiments on models. Application to the air resistance of projectiles shows how compressibility of the resisting medium is to be allowed for when the speed is high. Application to the screw propeller illustrates the treatment of a slightly less elementary problem, involving more variables, and shows how approximations, which are often unavoidable, may be introduced. The last problem treated is introduced for the sake of showing that the dimensional method is not restricted to the field of mechanics. It deals with an elementary case at heat transmission, and in the course of it some new points are brought out with regard to the practical working of the details of the dimensional method.

These illustrations—which might be multiplied almost indefinitely—have been selected with a view to elucidating some of the various devices which are of use in the practical application of new problems.

The method of reasoning is purely algebraic and therefore, in itself, rigorous. But while it cannot supply any new facts, because it is only mathematical and not physical, it often illuminates facts already known in a quite surprising manner, and sometimes permits our analysing and coördinating experimental data which without this guide seem hopelessly confused or contradictory.

## RATIONAL DESIGN AND ANALYSIS OF HEAT TRANSFER APPARATUS

By E. E. Wilson

The results of tests of heat transfer apparatus have been so inconsistent that the formulation of rational bases for design is precluded. This lack of agreement leads to the conclusion that some variable has been neglected, and a study of the results of tests on feed-water heaters and condensers leads to the belief that this variable is the viscosity of the circulating water. Since the accepted law for heat transfer is of the same general form as that for the resistance to flow in pipes, it seems likely that there is some close relation. It also seems probable that the effect of viscosity is of the same general character in each case, and on this assumption the published results for heat transfer are corrected in the same manner as are the results of Osborne Reynold's work on the resistance in pipes to flow of water through them. With this correction the results are reconciled, not only in an individual case, but for different experimentors as well.

If now these results as corrected, are put in the form of resistances to heat transfer, a linear relation is found to exist between the resistance and the reciprocal of the water velocity. The correction for viscosity may be put in this same form as a function of temperature. The resistance may then be evaluated in terms of its component parts and reduced to the form of an equivalent film of water of known thickness. These linear e. pressions may now be incorporated in a form giving the area of the heating surface required to transmit a given quantity of heat under the given flow conditions, in a condenser or feed-water heater. This expression seems rational in form and applicable throughout the range of practice, and in addition it seems possible through the use of the relations established to determine by experiment a similar expression for the resistance to heat transfer in other types of apparatus.

## PAPERS FOR THE SPRING MEETING

*Brief abstracts of the papers for the Spring Meeting, which have been assigned by the Committee on Meetings up to the time of going to press, are here published for the convenience of those who desire to secure advance copies. Announcement of additional papers will be made in the next number of The Journal. All of the papers for the Spring Meeting will be printed in pamphlet form in advance for distribution, and copies of any or all of them will be sent to members prior to the meeting upon application to the Secretary. After the meeting extended abstracts of the papers and an account of the proceedings, with discussion, will appear in The Journal, so that members will have early information concerning the events of the meeting, together with material that was presented. Finally, the papers, together with the discussion, will be printed in complete form in the annual volume of Transactions for 1915 for permanent reference*

## INFLUENCE OF DISK FRICTION ON TURBINE PUMP DESIGN

By F. zur Nedden

The mathematical survey of the problem leads to these conditions for a minimum loss through disk friction:

*a* Smoothness (polish) of both disk and casing. Roughness of either is equally detrimental.

*b* Smallest possible surface of both. Excessive extension of surface is equally detrimental whether it is the surface of the disk or of the casing.

*c* Outward indication of attainment of minimum is the fact that waste-water rotates half as fast as impeller.

A gyrostatic pressure is generated by the rotation of the waste-water and added to static pressure prevailing at periphery of impeller.

From the influence of the width of the impeller it follows that it is important to keep the thickness of metal at the periphery as small as possible. Protruding rims are objectionable.

The influence of the ordinary roughness of non-machined castings has no perceptible effect on the efficiency except with high lift pumps. Painting or japanning the surfaces generally seems less desirable than machining them with a medium heavy cut. High polish seems wasted. The experiments verify conclusion of mathematical survey.

The influence of viscosity is proportional to its fifth root; yet, it is responsible for an improvement in the efficiency of hot-water turbine pumps. The effect of pumping heavy oil and tarry liquid is estimated. The influence of fluid density is almost exactly proportional to the specific gravity.

The loss through disk friction constitutes a constant percentage of the useful power at all speeds in one and the same pump. Generally its percentic value grows with the value of $\frac{\text{Head per stage}}{\text{Capacity}}$ at constant speed, and diminishes with increasing speed and constant ratio $\frac{\text{Head per stage.}}{\text{Capacity}}$ High heads are more economically produced by high speeds or a greater number of stages than by increasing the diameter of the impellers, but the number of stages should be left to the discretion of the makers, not fixed by specifications. A steep angle between impeller blades and the tangent at the periphery serves very considerably to improve the efficiency owing to indirect reduction in disk friction losses, especially in high lift pumps.

The disk friction reaches a minimum for a certain width of the waste water chamber which is about ⅝ in. for disks of 12 in. diameter. The increase with increasing width is due:

*a* To the increase in retarding surface

*b* To the induction of secondary or induced hydraulic currents.

Concentric ribs are advantageous, radial ribs are detrimental.

In single-stage pumps the rotation of the waste water reduces the tendency for leakage by about 20 to 35 per cent. In multistage pumps the same influence may even increase the leakage.

Inequality in shape or roughness of the waste-water chambers on both sides of the impellers produce a gyrostatic axial thrust due to disk friction which can assume very considerable values. The direction of this thrust is indicated by the rule. The impeller is drawn to the side where the waste-water rotates farthest.

## A STUDY OF AN AXLE SHAFT FOR A MOTOR TRUCK

By John Younger

The shaft in question is the driving shaft on a large motor truck which transmitted 16½ h.p. at 27 rev. per min., and gave trouble by breaking after some service. The conditions of the shaft were investigated very closely and the methods by which, first of all the design was improved, are given in detail. It was found, however, that this was not sufficient and the only problem left was as to whether the material could not be improved. It was impossible to increase the size of shaft without running into various difficulties and experiments were made to improve the strength of material. It was finally found that by suitable heat treatment the elastic limit of the shaft could be raised to 175,000 lb. per sq. in. Experience with these heat-treated shafts has now extended over a period of two years, during which the results have been perfectly satisfactory.

## CORRUGATED FURNACES FOR VERTICAL FIRE TUBE BOILERS

By F. W. Dean

This paper discusses the advantages of using corrugated furnaces for vertical boilers, and gives as advantages the absence of staybolts and a slight amount of elasticity. It also speaks of the different sizes that can be obtained and the horse power of boilers that can be realized from furnaces of the largest size now made, and states some points to be borne in mind when making a design of such furnaces. It also speaks of their behavior under hydrostatic test, and of the proper method of flanging the fire door opening. The paper gives illustrations of two boilers with such furnaces that are now in use.

## THE EFFECT OF RELATIVE HUMIDITY ON AN OAK TANNED LEATHER BELT

By William W. Bird and Francis W. Roys

A careful study of the effect of changes in the relative humidity on a 4-in. single oak tanned leather belt was made and the results analyzed.

The effect most closely connected with the use of leather belting for power transmission was found to be in the lengthening of the belt with an increase in the relative humidity. This change in the length of the belt reduces the belt tension provided the distance between the pulley centers remains constant. This effect varies with the relative humidity, but is greater at high temperatures and less at low temperatures, but not in direct proportion to the absolute humidity.

The conclusions are that the relative humidity should be considered when a belt is tightened, the initial tension being made less for high relative humidities and greater for low; that a spring or gravity tightener should be used if it is desired to eliminate the effect of changes in humidity.

Leather is more or less of an uncertain material, the treatment and quality varies and hence these conclusions should be considered only in a general way.

## THE RELATION BETWEEN PRODUCTION AND COSTS

By H. L. Gantt

In the past it has been pretty common practice to make the product of a factory at a portion of its capacity bear the whole expense of the factory. This has been long recognized by many to be illogical, but so far there has not been presented a rational theory as to what proportion of the expense such a product should bear.

Mr. Gantt offers the theory that the amount of expense to be borne by the product, should bear the same ratio to the total normal operating expense, as the product in question bears to the normal product, and that the expense of maintaining the idle portion of the plant ready to run is a business expense not chargeable to the product made.

This latter expense is really a deduction from profits, and shows that we may have a serious loss on account of having too much plant, as well as on account of not operating our plant economically.

## DESIGN OF RECTANGULAR CONCRETE BEAMS

By Howard Harding

The resisting moment of a reinforced concrete beam may be represented by the formula $M = Rbd^2$ where $b$ is the breadth, $d$ is the depth and $R$ is a numerical co-efficient depending upon $E_s \div E_c\ f_s\ f_c$ and the percentage of steel reinforcement.

The paper outlines the development of two graphical diagrams, for the direct solution of the above equation. By their use the usual "cut and try" operations are eliminated. The diagrams are of the logarithmic form and since all the lines are straight and either horizontal, vertical, or at about forty-five degrees, the mechanical work of determining intersections is greatly facilitated.

By use of the first diagram the dimensions of beams just strong enough to withstand safely any desired bending moment are determined.

The second diagram gives factors by which the dimensions obtained from the first diagram are multiplied in order to correct for the bending moment due to the dead weight of the beam itself.

The beam should be checked for shearing stresses, and shear reinforcement added where necessary.

At the end of the paper a typical example is worked out in detail and a suggested form of computation is given.

## SOME MECHANICAL FEATURES OF THE HYDRATION OF PORTLAND CEMENT AND THE MAKING OF CONCRETE AS REVEALED BY MICROSCOPIC STUDY

By Nathan C. Johnson

Little has been actually known of the basic relations between the various materials entering into the composition of concretes. With a view to determining these, methods similar to those employed in the microscopic study of the structure of steels have been applied to a study of concretes.

As a result, new knowledge has been obtained with re-

gard to the functions of the various dissimilar ingredients of the concrete and as to the detrimental effects of foreign impurities, such as entrained air; and explanation is offered as to why, even with the best of materials, only low-strength structural material is obtained.

The production of binding substance, through the hydration of cement is also investigated by the microscope and a surprisingly low efficiency of use is found to obtain in all concretes. This relates further to the permanency of underwater concretes and reasons for failures are demonstrated and explained.

### SURFACE CONDENSERS

By Carl F. Braun

This paper presents the matter of the surface condensation of steam in connection with the most recent developments in condenser design and construction. The application of the logarithmic mean temperature difference between the steam and cooling water is taken up with reference to the counter current and parallel current system of circulation and a number of curves developed for the determination of the mean temperature difference.

The conditions affecting the variation of heat transfer through condenser tubes are carefully analyzed and presented in an original manner.

The main feature of the paper is its presentation of the principles of condenser design which are held to be correct theoretically and mechanically and the application of the principles involved to recent developments in the construction of condensers. The matter of steam circulation throughout the condenser is thoroughly discussed and the great importance of this point dwelt upon. The paper in the whole though presenting nothing startlingly new, discusses an old subject in a new and original way and points out the laws along which the modern surface condenser is developed.

## COUNCIL NOTES

At the meeting of the Council on April 9, 1915, the President announced the following appointments: Tellers of Election, H. A. Hey, Chairman, H. P. Hayes and R. H. Kirk; Committee on Classification of Engineering Literature, F. R. Low, Chairman, L. P. Breckenridge, W. W. Bird, A. E. Forstall and E. J. Prindle; this committee to coöperate with the Committee of the American Gas Institute, and also to report on a similar matter from a recent meeting of members in New York and referred by the Council to this committee.

Coöperation has been requested by this Society in the movement to form a reserve corps of civilian engineers representing all branches of the engineering profession. The Council recorded its sympathy with the proposed movement and voted that the President appoint a committee of five to coöperate with the War Department and committees of the other societies, who have taken similar action.

The Committee on Public Relations, and the Society's representatives on the Conference Committee of the National Engineering Societies, are authorized to be present at the State Constitutional Convention, and to coöperate with the other engineering societies at conferences.

A communication was received from the American Association for the Advancement of Science asking that this Society assist in formulating plans to improve the present method of securing expert testimony.

Voted: That the Society coöperate with other technical societies in any movement having for its object better practice in the use of the expert testimony of engineers in court proceedings, and that a special committee of five be appointed by the Chair, to carry on such coöperative work, such a committee to include in its membership one member experienced in the use of expert testimony in patent causes, one in the use of expert testimony of engineers in accident cases, and one in the use of experts in valuation cases.

The names of A. R. Baylis, A. M. Houser, Julian Kennedy and W. M. White were announced as the additional members of the Committee on Hydraulic Flanges of which the Council had named H. G. Stott as Chairman.

Voted: To approve and appoint as a local committee on meetings of the Society in Worcester, Mass., the following, duly nominated at a regularly called meeting of members in Worcester and vicinity: P. B. Morgan, Chairman; E. H. Reed, Secretary; C. F. Dietz, F. W. Parks and H. P. Fairfield.

Prof. Frederick R. Hutton reported that the Committee on the Sir William H. White Memorial had forwarded a draft for 60 pounds, to the Committee in England in charge of this memorial.

Voted: That a committee of five be appointed by the Chair to formulate general principles for the guidance of those who may serve the Society in a respresentative capacity and particularly when dealing with public questions.

## APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote.

These candidates will be balloted upon by the Council unless objection is received before June 10, 1915.

## NEW APPLICATIONS

### FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Ambler, Nathan B., Supt., The Toronto Pwr. Co., Ltd., Niagara Falls, Canada

Bettis, William I., Designing Engr., Layne & Bowler Corp., Los Angeles, Cal.

Bohn, Gebhard C., Vice-Pres., White Enamel Refrigerator Co., St. Paul, Minn.

Boyd, H. L., Ch. Safety Engr., Dept. of Safety, State of Cal., Los Angeles, Cal.

Chambers, Albert N., Walker & Chambers, Engrs. and Contractors, New York

Coppage, Benjamin D., Ch. Engr., The Pusey & Jones Co., Wilmington, Del.

Dickinson, Arthur R., Te tile Rep., Lockwood, Greene & Co., Atlanta, Ga.

Flagg, Charles N., Jr., Secy., The Taylor-Flagg Co., Meriden, Conn.

Griswold, Howard L., Mech. Engr., Central Cal. Traction Co., Stockton, Cal.

Hawes, Alex. G., Asst. Supt. Central Deleias, Cuban Amer. Sugar Co., Cuba.

Hayward, Judson, Secy. and Genl. Mgr., The Hayward Co., New York.

Hoffenreffer, Rudolf F., Pres., Fall River Water Board, and Treas. and Genl. Mgr., Old Colony Brewing Co., Fall River, Mass.

Hope, Walter R., Ch. Draftsman, E. I. du Pont de Nemours Powder Co., Wilmington, Del.

Kasley, John H., Engr. of Layouts, Western Elec. Co., Hawthorne, Ill.

Lanigan, James A., Fdy. Supt., Frontier Iron Wks., Buffalo, N. Y.

McCracken, William C., Ch. Engr. and Supt. of Bldgs. and Grounds, The Ohio State Univ., Columbus, Ohio.

Morse, Robert W., Asst. Examiner U. S. Patent Office and Asst. Prof. of Mech. Engrg., The George Washington Univ., Washington, D. C.

O'Brien, John E., Asst. Mech. Supt., Missouri Pacific Rwy. Co., St. Louis, Mo.

Stephenson, Thomas U., Pres. and Mgr., Knoxville Iron Co., and The Cross Mountain Coal Co., Knoxville, Tenn.

Stoddard, Clifford J., Ch. Insptr., Employers Liability Assurance Corp., Boston, Mass.

Tollerton, William J., Genl. Mech. Supt., Chicago, Rock Island & Pacific Ry., Chicago, Ill.

Walser, Arthur, Dist. Mgr. Motor Dept., General Electric Co., Denver, Colo.

Wheatley, Arthur W., Vice-Pres. and Genl. Mgr., Canadian Locomotive Co., Kingston, Ont., Canada.

White, Alfred D., Service Engr., Green Engineering Co., East Chicago, Ind.

Zanke, George J., Dist. Sales Mgr., American Engrg. Co., Chicago, Ill.

### FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Ballou, F. H., Traveling Engr., Great Western Sugar Co., Denver, Colo.

Bryen, Thomas T., Mech. Engr., Mesta Machine Co., Pittsburgh, Pa.

Carlson, Carl T., Ch. Engr., Springfield Boiler & Mfg. Co., Springfield, Ill.

Carver, Edgar M., Res. Rep., Dodge Sales & Engrg. Co., and Dodge Mfg. Co., Indianapolis, Ind.

Hubbard, Frank B., Asst. Plant Engr., Pierce Arrow Motor Car Co., Buffalo, N. Y.

Huntar, Felix, Asst. Engr. Mchy. Dept., American Can Co., New York

Kemp, Francis I., with Henry R. Worthington, St. Louis, Mo.

Kent, Herbert S., Draftsman, with Charles B. Rearick, New York

Kulling, Otto W., Asst. Engr., with Albert C. Wood, Cons. Engr., Philadelphia, Pa.

Meserole, Kenneth A., Engrg. Dept., American Beet Sugar Co., Oxnard, Cal.

Ross, Alastair, Ch. Engr., Central Soledad Sugar Factory, Guantanamo Sugar Co., Guantanamo, Cuba.

Smith, Harold A., Foreman Mech. Dept., Amoskeag Mfg. Co., Manchester, N. H.

Trenfield, Ernest J., Asst. Mech. Engr., Orconera Iron Ore Co., Ltd., Luchana, Bilbao, Spain.

Walker, William C., Tech. Asst., Semet Solvay Co., Syracuse, N. Y.

Watson, Jay E., Draftsman, The George W. Blabon Linoleum Co., Nicetown, Philadelphia, Pa.

Williams, William W., Genl. Draftsman, Brooklyn, N. Y.

### FOR CONSIDERATION AS JUNIOR

Allentuch, James, Instr., Genl. Elec. Engrg. School, Lynn, Mass.

Bernard, Harold B., with The Industrial Instrument Co., Foxboro, Mass.

Githens, Thomas F., Asst. Engr., American Sugar Refining Co., Brooklyn, N. Y.

Hill, Dudley M., with Industrial Inst. Co., Foxboro, Mass.

Junkins, John N., Engr., Aberthaw Constr. Co., Boston, Mass.

Lincoln, Howard A., Mech. Engr., Strathmore Paper Co., Woronoco, Mass.

McCart, Raymond D., Student, Massachusetts Inst. of Tech., Boston, Mass.

Mahoney, John F., Draftsman, Fire Dept., New York.

Maurer, Rolland E., Cadet Engr., Utah Gas & Coke Co., Salt Lake City, Utah.

Trego, A. C., Indus. Engr., Workmen's Compensation Service Bureau, New York.

Wigren, Clarence F., 641 49th Street, Brooklyn, N. Y.

## APPLICATIONS FOR CHANGE OF GRADING

### PROMOTION FROM JUNIOR

Wilcox, Carl C., Asst. to Cons. Elec. Engr., Hodenpyl, Hardy & Co., Jackson, Mich.

## SUMMARY

| | |
|---|---|
| New Applications | 52 |
| Applications for change of grading: | |
| Promotion from Junior | 1 |
| | 53 |

# GAS PRODUCERS WITH BY-PRODUCT RECOVERY

BY ARTHUR H. LYMN,[1] LONDON, ENGLAND

Non-Member

THE art of generating producer gas from coal is a very old one, but the development of the simultaneous recovery of the valuable by-products is comparatively recent, having been confined to the last twenty-five years or so. The object of this paper is to present a historical resumé of this development in Europe, and also to outline some of the latest features of the Lymn system of by-product recovery for which the author has been responsible.

The early attempts in Europe to recover the by-products of the producer gas process are generally recognized to have been made in Great Britain. In that country the knowledge that the treatment of fuel by a mixture of steam and air (the former in excess) would convert a large percentage of the nitrogen contained in the coal into ammonia was first applied in practice on a large scale. The details of a plant to operate on this principle had always been worked out by Messrs. Young and Beilby in England and Grouven in Germany among other investigators.

The gas producer designed by Young and Beilby differed in operation from the ordinary by-product gas producer in that it was heated from the outside. The coal was distilled in the upper part of the producer or retort and the tar vapors passed down through red hot coke and were (it was claimed) decomposed into permanent gas and ammonia. The coke in the lower half of the producer was burned in a mixture of steam and air and the resulting gases, together with the gaseous products of the coal distillation, passed out of the producer by way of exits at the middle. The arrangement is shown in Fig. 1.

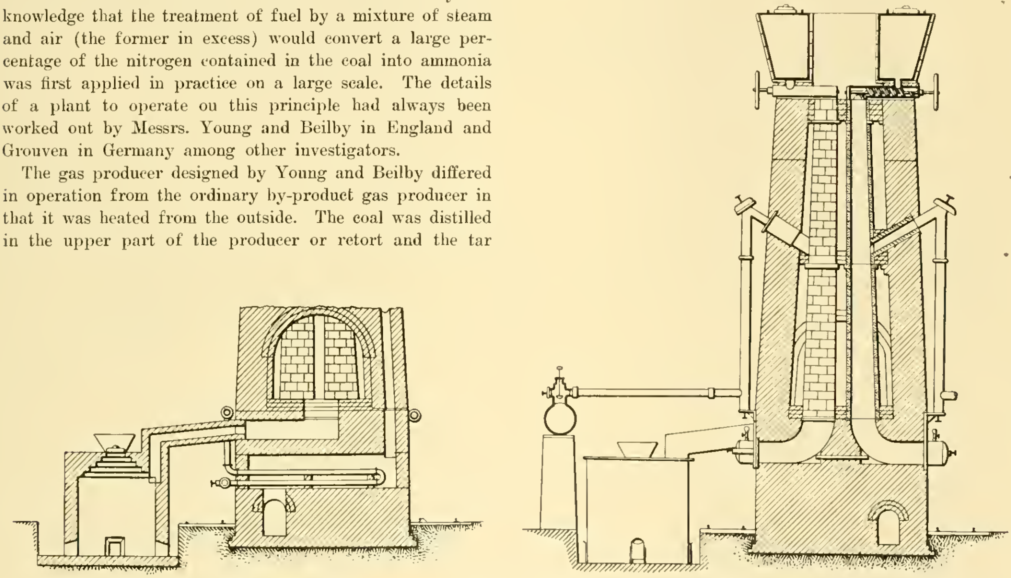


FIG. 1 YOUNG AND BEILBY'S BY-PRODUCT GAS PRODUCER

It is particularly interesting to note that, as far back as 1883, Young and Beilby claimed to recover in the form of ammonia from 60 to 70 per cent of the total nitrogen in the fuel and that the percentage composition of their gas was:

| | |
|---|---|
| Carbonic acid | 16.6 per cent |
| Carbonic oxide | 8.1 per cent |
| Methane | 2.3 per cent |
| Hydrogen | 28.6 per cent |
| Nitrogen | 44.4 per cent |

Although their retort was heated from the outside instead of the air and steam blast being superheated, it will be seen that the results claimed by them as to ammonia were not far short of what we realize to-day. The gas composition, too, was practically the same as that of the gas which has since become so widely known as Mond gas and which has the following percentage composition:

| | |
|---|---|
| Carbonic acid | 14 to 16 per cent |
| Carbonic oxide | 10 to 12 per cent |
| Methane | 2 to 3 per cent |
| Hydrogen | 25 to 29 per cent |
| Nitrogen | Difference |

The above makes it obvious that Dr. Mond was not the first investigator to produce gas of this composition.

It is now rather more than twenty-five years since the late Dr. Ludwig Mond first put into commercial practice the process described in his British Patents No. 3821 of 1883 and 8973 of 1885, of gasifying fuel by means of steam and air and simultaneously recovering the ammonia. His first plant was installed at the works of Brunner, Mond and

[1] Sanctuary House, Tothill Street, Westminster, S. W., London, England.

Presented at the New York local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on November 10, 1914.

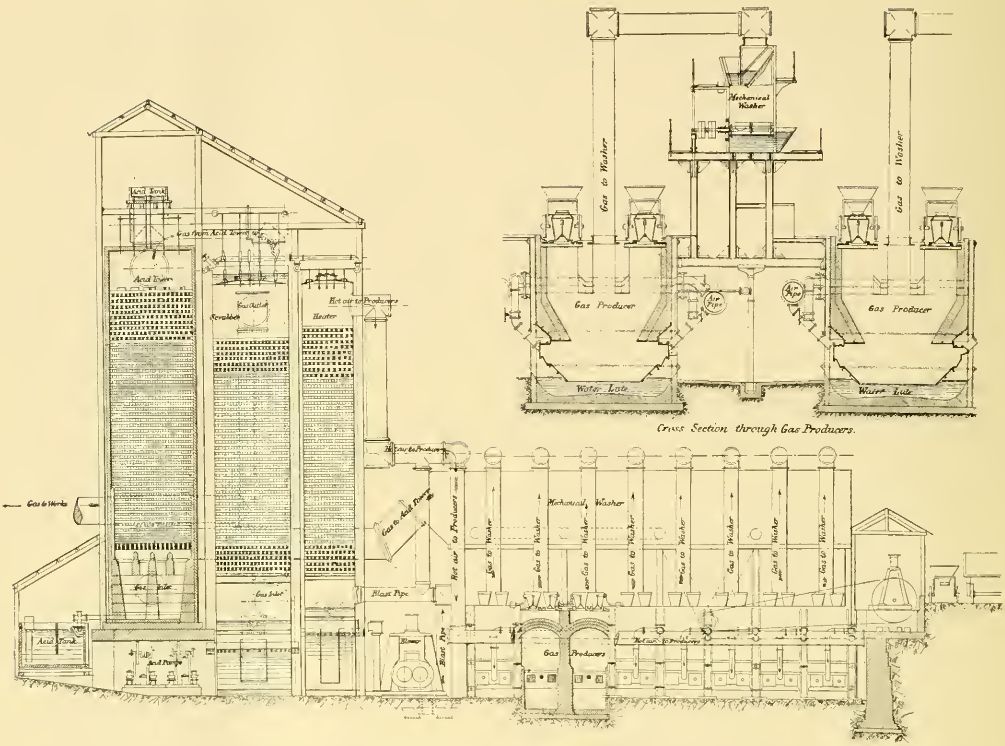



FIG. 2 MOND SYSTEM PRODUCER GAS AMMONIA RECOVERY PLANT

Co., Northwich, England, and its capacity was developed to some 200 tons a day. Unfortunately this plant was not in a good position to be photographed, but a diagram of it is given in Fig. 2.

The Mond producer was rectangular in section and was formed with a kind of double chamber. Its operation was similar to that of Young and Beilby, in that the coal was distilled in a downward direction in the upper part and the coke residue was gasified in the lower part, all the gases mixing and leaving the producer together. The gas was passed into a long horizontal rectangular washer and a fine spray of water was thrown into it by a series of revolving dashers. By this means a large proportion of the dust was removed, which was afterwards taken out of the water lute manually with long scoops, an irksome operation. From the washer, the gas was conducted into a high lead-lined acid tower (filled with earthenware ring tiles) where in passing upwards it came into contact with sulphate of ammonia solution trickling down. This solution contained a slight excess of sulphuric acid and deprived the gas, by absorption, of nearly all the ammonia contained in it. From this tower, the gas was passed into a similar tower, called the scrubber, where it was brought into contact with cool water for scrubbing and cooling it and it was then delivered for use.

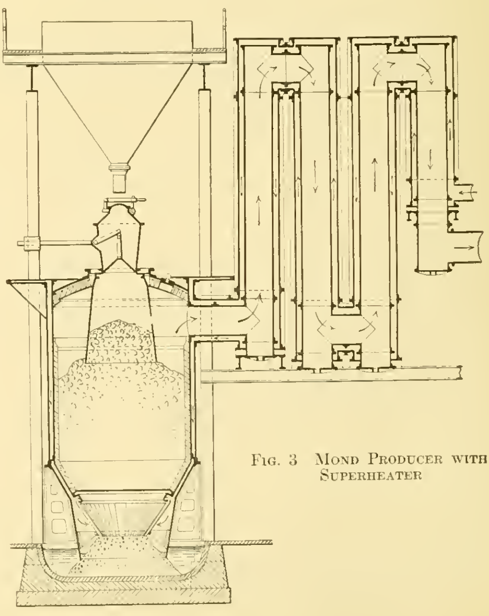


FIG. 3 MOND PRODUCER WITH SUPERHEATER

The water, having taken up the heat of the gas, was collected in tanks from which it was introduced into the heater,

also of tower construction. It was here brought into contact with the cold air to be used in the producers, saturating this air with water vapor at from 70 to 80 deg. cent. and becoming again cooled. Then it was returned to the scrubber, where it again took up the heat of the gas, and so on in a continuous cycle.

After this plant had been in operation for some time, it was found that, owing to the large proportion of steam in the air blast, the heat value of the gas was below the desired standard and also the yield of ammonia was less than that which Dr. Mond had set out to obtain. It was therefore decided to change the design of the gas generating part of the plant so that the air and steam blast would enter the producer with a considerable degree of superheat, thus enabling a still greater excess of steam to be used. This modified design was disclosed in Mond's British Patent No. 12,440 of 1893 and is shown in Fig. 3. The producer was made circular in section instead of rectangular and its whole shell was surrounded by a jacket through which the air was passed on its way to the grate, reducing the losses from radiation and at the same time further superheating the steam and air blast. Directly contiguous to the producer was arranged a superheater, consisting of a series of parallel tubes with alternate ends connected, surrounded by a series of larger tubes forming an annular space. The gas from the producer passed through the inner tubes and superheated the steam and air blast which was passed through the annular space in a counter-current direction on its way to the producer. With this provision, the gas was found to possess a much higher heat value and a considerably increased yield of ammonia was obtained without extra fuel.

It is interesting to note that Dr. Mond, with that great courage in engineering undertakings for which he was famed in

FIG. 4 MOND GAS CENTRAL STATION AT DUDLEY PORT, ENGLAND

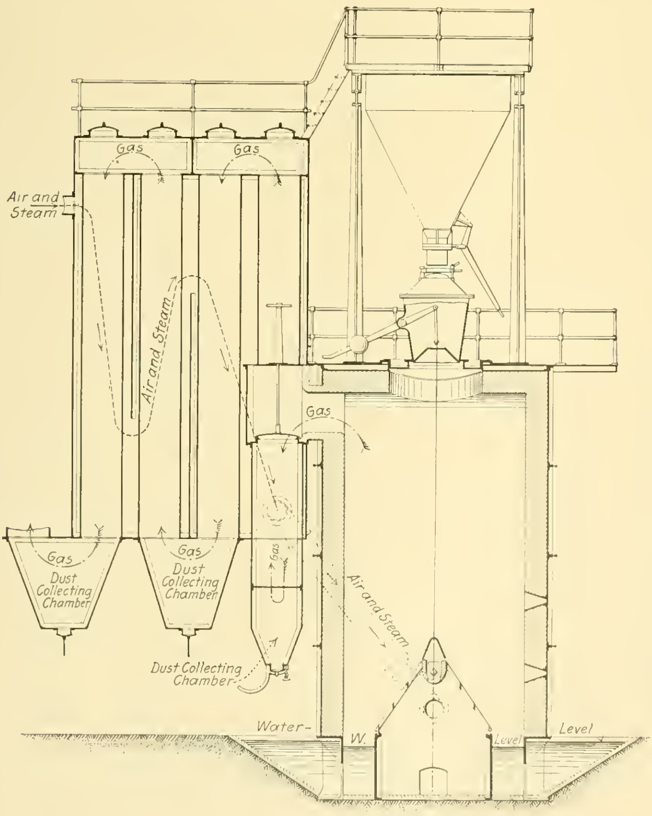



FIG. 5 DUFF PRODUCER WITH SUPERHEATER

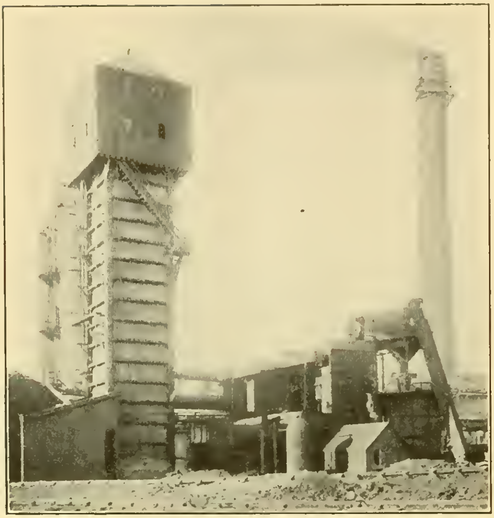


Fig. 6 Duff Plant at Fleetwood, England

the days of his greatest activities, built a very large unit plant at the outset, and smaller plants in later years. This was contrary to the usual order of things, and discloses the reason for the widespread idea that by-product producer plants were only profitable when built in very large and costly units.

Among the plants built by Dr. Mond or his successors in England—The Power-Gas Corporation—the central station at Dudley Port, Staffordshire, for the distribution of Mond gas over an area of about 120 square miles, through about 30 to 40 miles of pipes, is of particular interest. The author had charge of this plant for some time. The gas from this station is supplied to iron and steel works, machine shops, foundries, galvanizing works, pumping stations, enameling works and municipal electric stations. The installation had originally a capacity of 16,000 h.p., which has just recently been largely increased. A general view of this plant which is familiar to many engineers in this country is shown in Fig. 4.

The Dudley Port plant is quite unique in that it is the only central station in the world designed and built for the distribution of producer gas. The gas is sold to consumers in competiion with coal, ordinary lighting gas and electricity. The advantages to be derived from taking supplies of the gas were not apparent to the public for several years, but once they had been fully demonstrated the number of consumers rapidly increased.

Up to about the year 1897, Dr. Mond was constantly endeavoring to improve his process, but after that time he appeared to be satisfied with his design and in fact in advancing years he became adverse to any material modifications. The result was that the design of the Mond plants did not advance with the times and the writer is of the opinion that in those cases in America in which Mond system plants have not been so successful as was expected, it has been chiefly attributable to this factor and to the failure to realize that a certain state of reliability and efficiency in other countries, with quite different fuels and under totally unlike conditions, is not necessarily a criterion for exactly the same results in this country.

After Dr. Mond had demonstrated the success of his process, it was not long before another worker, E. J. Duff, claimed attention. As a whole Duff's plant embodied very little to distinguish it from the Mond plant, the same process being of course carried out in the two plants. Duff's producer was of rectangular section inside, with rounded corners, and his superheater, as shown in Fig. 5, consisted of a series of parallel gas tubes with alternate ends connected, surrounded by one chamber. Baffles plates in this chamber compelled the steam and air blast to take a zig-zag path on its way to the producer. Except for this slight difference in the construction of the superheater, which, however, occasioned no difference in the action of the producer, there was practically nothing to distinguish the Duff plant from the Mond plant.

Several large plants were constructed according to Mr. Duff's designs. One of these is shown in Fig. 6. This was erected at Fleetwood, England. The photograph does not show the producers very well but conveys a good idea of the great height and size of the towers for ammonia absorption, gas cooling and air saturation. These large towers are characteristic of the plants of this construction. It is well known in Great Britain that Mond and Duff were

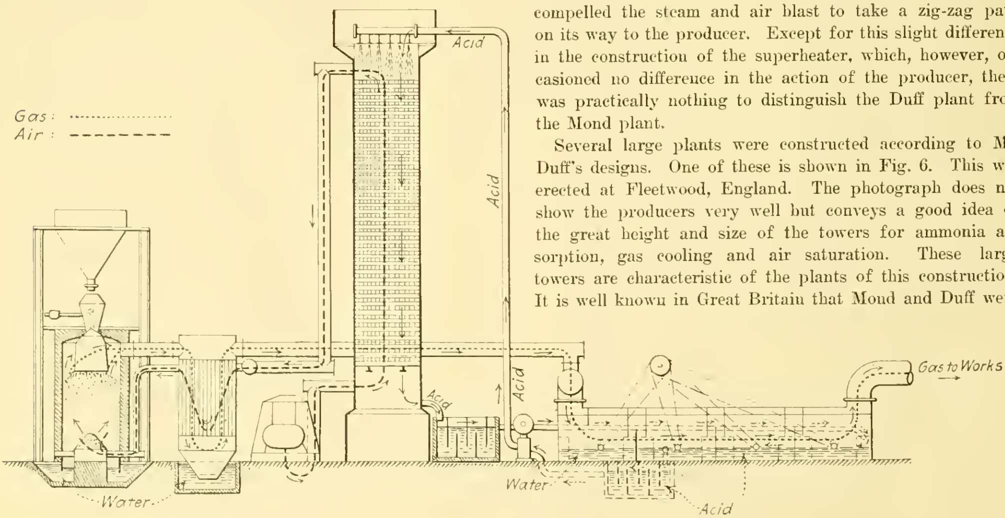



Fig. 7 Crossley and Rigby Patent Ammonia Recovery Plant

at one time in conflict in the matter of their patents, but that their interests were afterwards amalgamated into one company, The Power-Gas Corporation, formed in 1901. The patents in question have since expired in England, but it may be that some of Duff's American patents are still in force.

Messrs. Crossley Bros., of Manchester, were the next to claim material improvements, which, however, do not appear to have been realized in practice. In fact, it is the author's belief that some time ago this firm ceased altogether to build plants for the gasification of coal and the simultaneous recovery of the by-products. It is perhaps nevertheless of interest to include here a diagram of the first form of plant Messrs. Crossley Bros. adopted (Fig. 7).

Briefly the claims made for this plant were that the washing and cooling of the gases, as well as the condensing of the water vapor and the absorption of the ammonia, took place in one and the same apparatus, the ammonium sulphate liquor being utilized for the purpose of saturating the air with water vapor and the liquid being thereby cooled at the same time. As a matter of fact, in the first series of operations a washer made up of two compartments was used, and the gas would leave this apparatus in a more or less uncooled state and also practically saturated with water vapor at a compartively high temperature. Fig. 7 does not therefore show all the necessary apparatus.

The second claim made, that is, that the air was saturated by means of the sulphate liquor, represented a very dangerous practice. A fine sulphate of ammonia liquor spray, with its excess of highly-corrosive acid, would naturally be carried forward to the superheaters, etc., and with very obvious results. Messrs. Crossley Bros., as a matter of fact, took out later a patent for the utilization of the above system in combination with a somewhat costly bed of lime, which the saturated air had to pass through, clearly to absorb its contained acid spray.

The next step in the development of this process the author feels justified in claiming to have taken himself on the basis of his British Patent No. 8014 of 1908. This was an attempt to entirely dispense with the costly and irksome towers of the Mond and other plants, which became blocked up from time to time causing serious trouble and delay. The attempt was made by replacing the mechanical

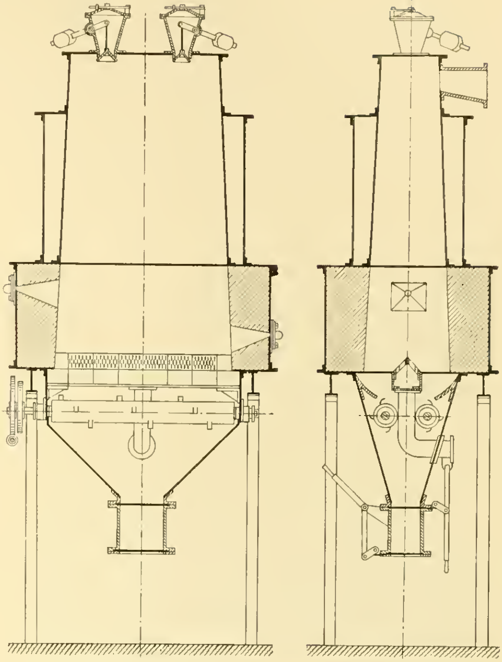



Fig. 9 Moore's Three-Part Producer

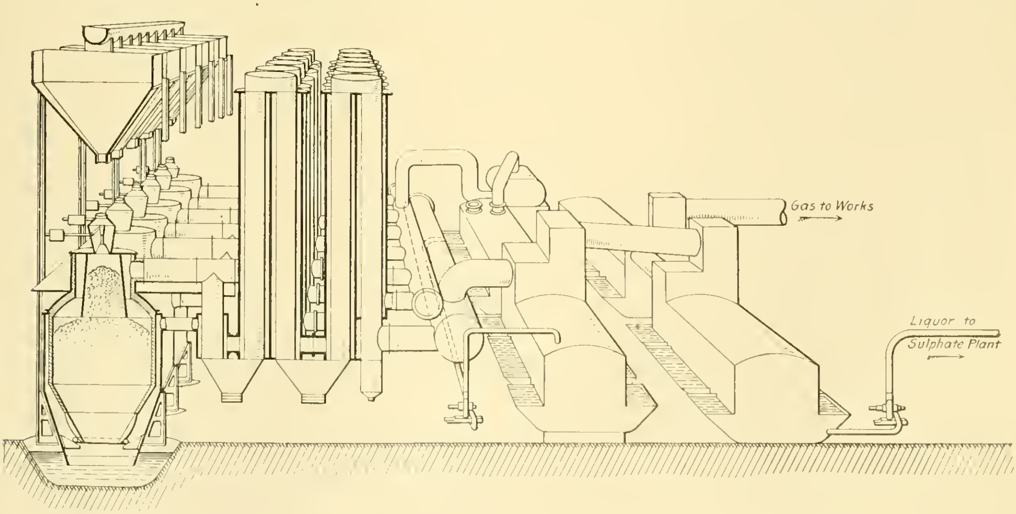



Fig. 8 Mond Type Ammonia Recovery Plant with Double Chamber Washers

washer and towers by washers of special construction, which obviously could not become blocked up. Four double washers were proposed, one for washing the gas, the second for absorbing the ammonia, the third for cooling the gas and the fourth for saturating the air. This design was later modified in favor of a double-luted washer and was changed a third time by The Power-Gas Corporation for a combination of double and single chamber washers upon the same principle. An idea of the general appearance of a plant with these washers may be obtained from Fig. 8.

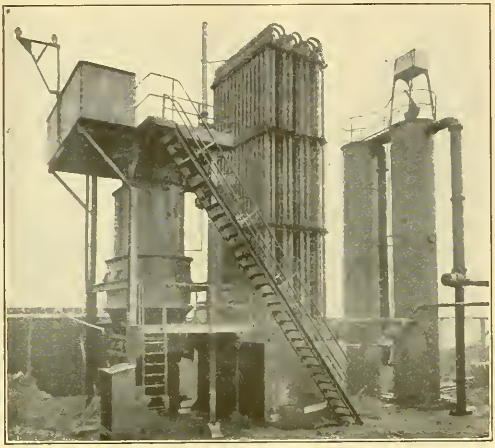


Fig. 10 Moore's Patent System By-Product Recovery Plant

Various modifications of ammonia recovery plants are also disclosed in patents taken out by A. B. Duff, of Pittsburgh. Notable among these is a producer with a circular grate and also a circular section superheater with four enclosed gas tubes. The former is illustrated in British Patent No. 16,164 of 1903 and the latter in British Patent No. 16,243 of 1903. These modifications have been adopted in Great Britain in two or three plants and are, I believe, working successfully with Scotch and other more or less non-caking coals.

In another design (British Patent No. 4372 of 1910) A. B. Duff claims that by passing the gas around the evaporator before entering the washers, its heat can be utilized for evaporating the sulphate of ammonia liquor. On first sight, this idea appears to be a good one, but it seems to the writer that great difficulty may be experienced in carrying it out in practice on account of the dust and tar present in the gas at this stage of the operations. Moreover, it must be borne in mind that in this design the gas is washed before it is allowed to enter the ammonia absorption tower, and that the washing water is used for saturating the air going into the producers. It therefore appears that the air will carry to the producers a not inconsiderable proportion of the ammonia which will thus be lost. The author is not aware of a plant on these lines having been built and put into operation, and is but meagrely informed concerning the earlier Duff plants built in the United States.

It may be taken that all the designs above referred to were, broadly considered, based upon what is generally known throughout the world as the Mond process. Two different propositions for the gasification of coal and the simultaneous recovery of the by-products will now be referred to.

The first of these is that by F. J. Rowan, of Glasgow, who proposed to combine the gas producer process with the usual process utilized in lighting gas works, viz., to replace the absorption of the ammonia by acid (as is done in the Mond process) by a condensing plant. He did not propose to actually produce the ammonia in any different way, and it is obvious that since, for every ton of coal gasified, approximately 150,000 cu. ft. of gas at normal temperature and pressure, together with about 1.5 tons of excess water vapor, are produced, an apparatus for condensing the ammonia cannot be otherwise than very excessive in size. Moreover, the gases enter the condensing plant at a temperature of 400 deg. cent. or more, at which temperature their volume is multiplied several times. The condensed ammonia liquor is extremely dilute and must be distilled with lime in the usual manner adopted in lighting gas works, a not very pleasant operation. These facts make the difficulty of carrying out this proposition obvious, and the writer is not aware that any plant was built on these lines. The author himself has tried surface cooling for by-product producer gas but has found firstly, that meterological conditions have too much influence on the result and secondly, that the apparatus required would be much more expensive owing to the large volume of gas to be dealt with and the lower rate of heat transference possible.

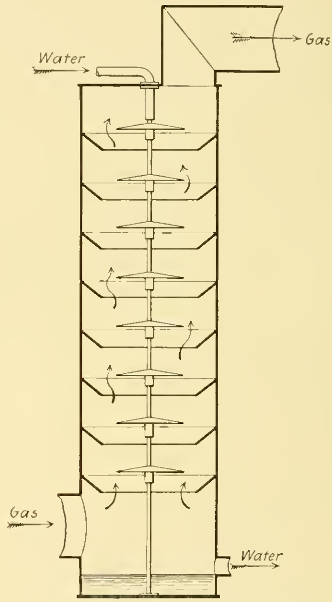



Fig. 11 Lymn Type Washer

The second proposition is that by Quintin Moore who designed a producer divided into three parts, a lower brick-

lined part, a middle water-jacketed part and an upper air-cooled part. The arrangement is shown in Fig. 9.

By this cooling of the upper part of the producer, Moore claimed to obtain a good yield of ammonia with about half the amount of steam in the air blast. It does not seem likely, however, that such cooling can penetrate far into the fuel bed, and it should not be overlooked that other workers, in particular the late Dr. Mond, previously considered the possibility of recovering ammonia by means of merely cooling the producer, but came to the conclusion (based on sound scientific knowledge) that cooling was not the only desideratum in ammonia recovery.

One can easily overrate, too, the importance of saving steam. In the Mond process, practically all the steam is generated from waste heat and, moreover, most of it is continuously recovered. Any further saving can only be secured at the expense of some of the sulphate of ammonia yield. At all events, Mr. Moore states in his published matter that he obtains more ammonia when he introduces more steam, hence his usual amount of steam does not produce the maximum ammonia recovery.

Fig. 10 illustrates a plant built on the Moore system. The small air-cooled tubes are so constructed and in such a position as to bring about great likelihood of frequent stoppage of the plant on account of tar and dust deposits. Whatever may be the results with this plant with non-caking coals, the plant does not seem to be applicable to caking fuels with any reasonable degree of efficiency. The only publication regarding this system which has come before the writer shows the results of tests of but five hours duration, which tests have obviously but little value for practical purposes.

Some five years ago the writer set out to design a new type of plant which should retain the advantages of previous types without their disadvantages. He was led to do this by the realization that, in spite of the extreme cheapness of producer gas as made by plants operating under the Mond system and although a considerable number of plants had been built and operated in a somewhat restricted number of countries, the adoption of the producer gas process had not become general throughout the industrial world. Careful investigations of the situation led to the conclusion that although the process as such was, and is, really good, the means adopted for carrying it out left much to be desired, especially from the point of view of capital outlay, labor requirement, repair costs and simplicity of operation.

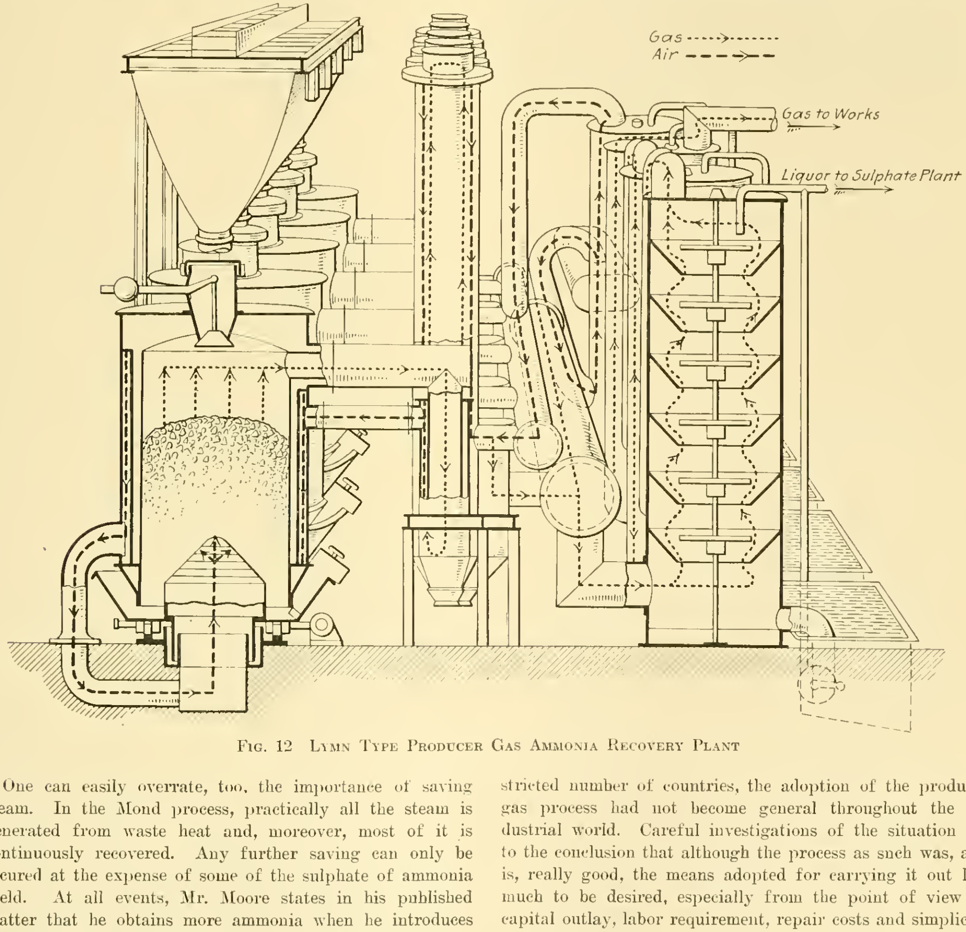



Fig. 12 Lymn Type Producer Gas Ammonia Recovery Plant

These drawbacks were inherent primarily to the ammonia absorption, gas washing, gas cooling and air saturating elements of the plant. All these operations were heretofore carried out in high and cumbersome towers packed with earthenware ring tiles, or in equally cumbersome horizontal luted dasher washers, both of which the author set out to replace.

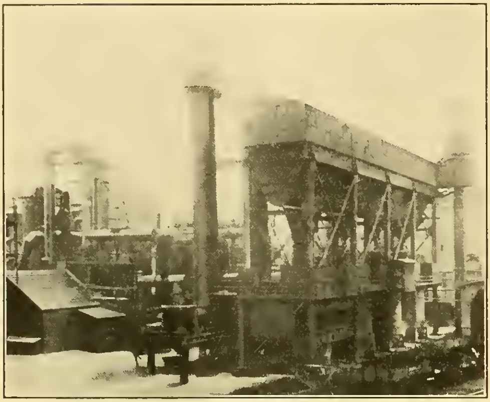


Fig. 13 8000 H.P. Lymn System Producer Gas and By-Product Recovery Plant

A system of vertical washers, in which an intensive washing of the gases was brought about chiefly by means of the momentum of the gases, was first designed and put into practice. Vertical mechanical washers had not previously been used in gas producer plants and the writer first designed one on the lines already known in other branches of the gas industry, in which the washing liquid was sprayed by means of a series of co-axial revolving discs onto collecting cones, each of which delivered the liquid directly onto the next revolving disc below, and so on. It was found, however, in setting this washer to work, that with such an arrangement, the momentum of the gas was performing much more work than was the mechanical movement of the discs, a rather surprising fact. Accordingly, the mechanical feature of the washer was eliminated, the collecting cones were cut away to give the gas more play and the washer now had the appearance as shown in Fig. 11. It will be seen that if plumb lines are taken down the inside edges of the collecting cones and down the outside edges of the discs, a considerable space exists between them, which is such in practice that, if no gas is passing, the water entering at the top falls straight down to the bottom.

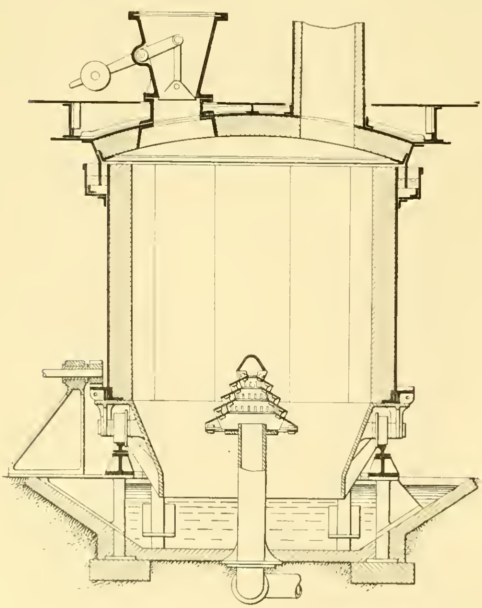


Fig. 14 Duff Patent Revolvable Producer

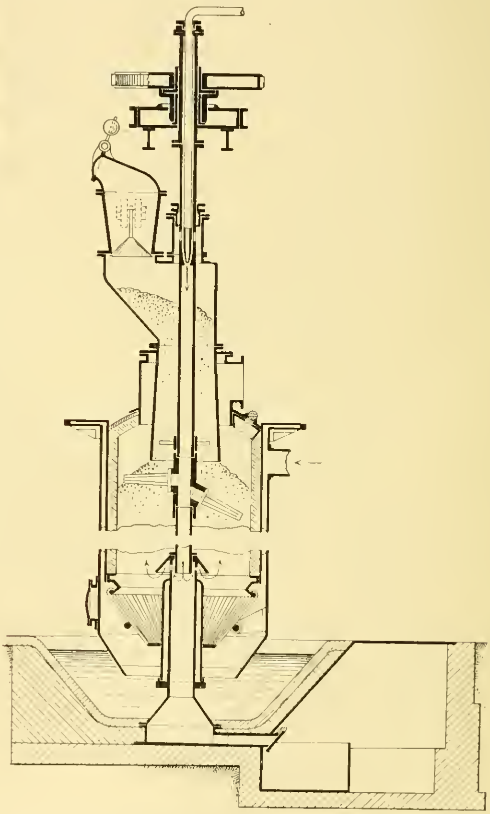


Fig. 15 Mond Producer Combined with Talbot Stirrer

With this modified washer, a plant originally designed to deal with the gas from 45 to 50 tons of coal per day was able to deal with that from 90 to 100 tons per day, so that the capital outlay of the gas washing part of the plant was straightway reduced one half. Such washers have now been in operation for approximately two years with entire success, and it is now possible to design washer units of this particular type to deal with quantities of gas from 10,000 up to about 1,300,000 cu. ft. per hr.

Fig. 12 illustrates the general appearance of a plant with these Lymn washers. The dimensioning of the washers is not a very simple matter, being of necessity purely empirical, and the author has arrived at the dimensions en-

tirely by stepwise trial, which has obviously not been done without considerable expense.

If Fig. 12 is compared with the previously shown diagrams of other plants, it will be seen that the whole apparatus looks much less cumbersome and obviously simpler in operation, involves less auxiliary machinery and consequently less first cost. It will be further noted that in the

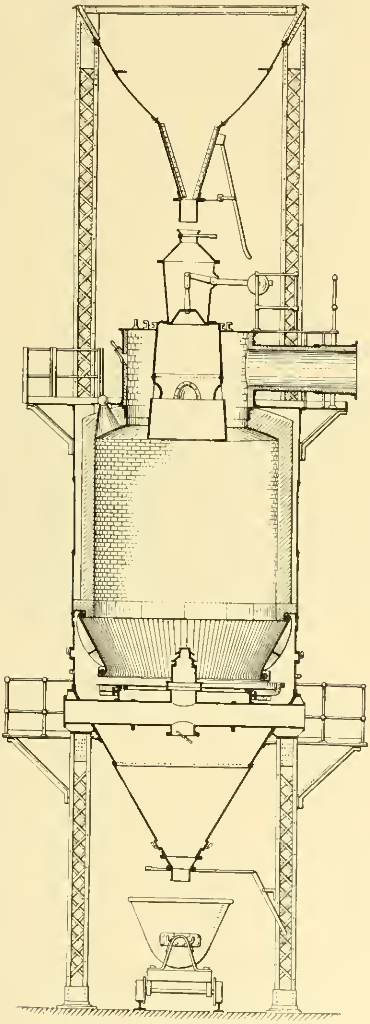


FIG. 16 MOND-TRUMP PRODUCER WITH DRY ASH DISCHARGE

Lymn system exactly the same kind of apparatus is employed for each of the operations of absorbing the ammonia, cleaning the gas and recovering the steam. For the final stage of removing the last traces of tar, etc., however, centrifugal cleaners combined with dry scrubbers, or such methods as have been proposed by H. F. Smith, have to be utilized.

One other point to which attention might be drawn is that the Lymn plants do not contain any lead parts, steel being used for the parts of ammonia absorbing apparatus. A Lymn plant constructed with no lead whatever has been in operation in German for approximately four years and no corrosion has yet been discovered. This plant is shown in Fig. 13. Its capacity is 8000 h.p.

A second direction in which the author claims to have made considerable improvements is in the removal of dust. These improvements have been accomplished by the adoption of a cyclonic dust separator of somewhat special design.

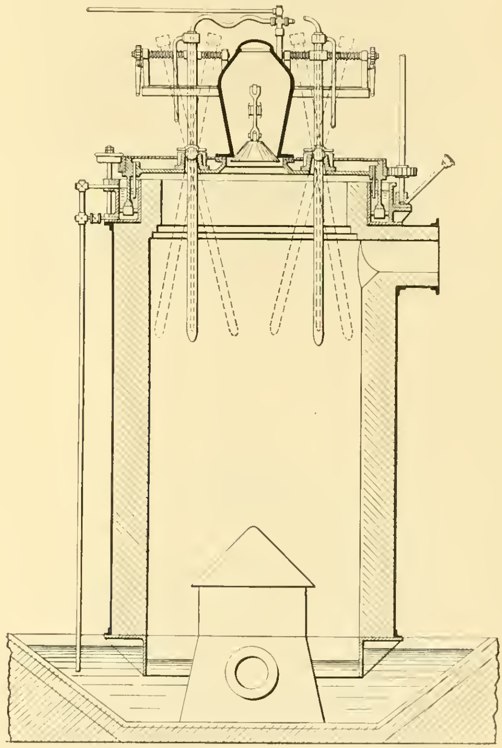


FIG. 17 A. B. DUFF'S PATENT MECHANICAL STIRRER

With this separator, the bulk of the dust is removed in a dry state and not by means of water, as in other plants. The removal of all the wet and sloppy dust from the earlier horizontal rectangular washers was a very troublesome proceeding, involving considerable costly manual labor, as will easily be realized.

In the gas producer itself, the writer has taken considerable pains to apply to ammonia recovery plants the mechanical action which has been so widely applied to ordinary gas producers, both in the United States and in Germany but not so much in England. This mechanical action involves agitation in the fuel and ash zones of the producer and mechanical ash removal. Many attempts in this direction of mechanical action have previously been made and some of them have met with more or less success. The writer

believes the first of such proposals was made by E. J. Duff, who designed an octagonal-section revolvable producer with a stationary grate, ash trough and top, as shown in Fig. 14. This design was disclosed in British Patent No. 15,646 of 1901, but the specification does not state that it was intended for ammonia recovery purposes, although, as far as the author's recollection goes, the inventor considered it primarily in this connection. The writer is unaware of any practical trial having been made of this producer.

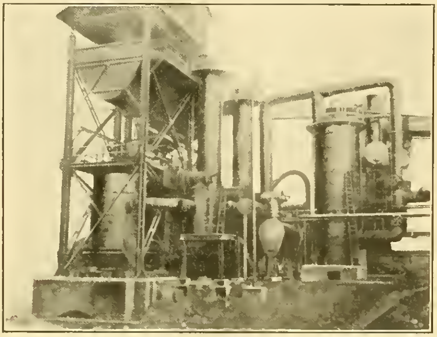


Fig. 18 First Section of a 13,000 H.P. Lymn System Producer Gas and By-Product Recovery Plant

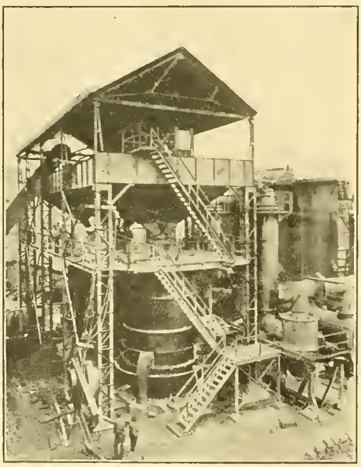


Fig. 19 5000 H.P. Lymn System Producer Gas and By-Product Recovery Plant During Erection

The next of these proposals was a combination of the well-known Talbot stirrer with the Mond producer. This was made by Dr. Mond himself and is shown in Fig. 15. This apparatus was tried out thoroughly with various coals of a more or less coking nature. It was very costly to install and its operation was not without difficulties. The writer does not know of any more producers of this type being built beyond the first.

Another attempt to adapt revolving producers to ammonia recovery plants was one made by the author, but although its trial was much hampered by the fact that the makers failed to build the device to drawings and specifications, it was certainly not sufficiently successful to warrant general adoption. The great depth of fuel requisite for ammonia recovery renders the operation of mechanical producers exceedingly difficult. One of the difficulties found by the writer in practice was that, when using a caking coal, the producer revolved while the coal remained more or less stationary, resulting only in the grinding of the coal at the periphery of the producer.

Another step in this direction was the combination with the producer of the mechanical ash removing apparatus designed by Mr. Trump. This combination is illustrated in Fig. 16 and has been adopted on a somewhat large scale. A battery of these so-called Mond-Trump producers was built in England and at the time of its installation the writer was hopeful that the combination, though very costly, would prove to be a valuable development; however, the information to hand regarding it is not very encouraging.

Fig. 20 Peat Power Gas Plant with Ammonia Recovery at Pontedera, Italy

Still another proposition is that made by A. B. Duff, in which a mechanically operated stirring poker is utilized in the producer (Fig. 17). This worked very well indeed when tried with Scotch washed nut and the writer believes it has been further adopted for use with this or similar coals. Scotch coal does not cake, however, and therefore with such coal there appears to be insufficient justification for incurring the additional cost of this stirring gear, except it be for the purpose of increasing the rate of gasification. The writer has had a great deal of experience with Scotch nut in stationary producers and has never had the slightest trouble with this coal. He would therefore be interested in the results obtained with this device when applied to English caking coals, and still more to those in this country.

The design of producer adopted in the Lymn plants was based on the principle which has been so largely utilized for ordinary hot gas producers in Europe, where the rotary grate and the mechanical ash removal have been further constructionally improved and very widely introduced both by Kerpely of Vienna and by the writer's German licensees. On the basis of the last-named firm's designs as adopted for hot gas producers, the system has been applied to ammonia recovery, material modifications being of course necessary.

TABLE 1 ACTUAL OPERATING RESULTS OF POWER GAS PLANT (LYMN SYSTEM)

Driving Large Gas Engines and Firing Furnaces

| First period of 4 weeks | Total | Average per day of 24 hours | General Average |
|---|---|---|---|
| Coal consumption of the gas plant | 1,806 tons | 64.6 tons | Per kw-hr. 1.58 lb. (0.72 kg.). |
| Power produced (kw-hr.) | 1,889.740 | ....... | Per hr. 2812 kw. |
| Yield of sulphate of ammonia | 49.11 tons | 1.76 tons | Per ton coal 60 lb. (27.1 kg.) |
| Yield of tar (containing water) | 189.7 tons | 6.78 tons | Per ton coal 230 lb. (105 kg.) |
| Average heating value of the gases | 155 B.t.u. per cu. ft. (1380 cal. per cu. m.) | | |
| Sulphur contained in the gas (average) | 0.63 grams per cu. m. | | |
| Tar contained in the gas (average) | 0.04 grams per cu. m. | | |
| The auxiliary machines consumed regularly 71 kw. | | | |
| Including 10 per cent depreciation the gas costs per kw-hr. work | out at 0.069 penny | | |
| Second period of 4 weeks | | | |
| Coal consumption of the gas plant | 1,967 tons | 70.2 tons | Per kw-hr. 1.72 lb. (0.78 kg.) |
| Power produced (kw-hr.) | 1,899,600 | ...... | Per hr. 2830 kw. |
| Yield of sulphate of ammonia | 54.3 tons | 1.94 tons | Per ton coal 61 lb. (27.6 kg.) |
| Yield of tar (containing water) | 231.7 tons | 8.27 tons | Per ton coal 257 lb. (117 kg.) |
| Average heating value of the gases | 154 B.t.u. per cu. ft. | | |
| Sulphur contained in the gas (average) | 0.38 grams per cu. m. | | |
| Tar contained in the gas (average) | 0.057 grams per cu. m. | | |
| The auxiliary machines consumed regularly 78 kw. | | | |
| Including 10 per cent depreciation the gas costs per kw.-hr. work | out at 0.07 penny | | |

Note:—The nitrogen efficiency during these two periods was 70 per cent. It is frequently 75 per cent.

TABLE 2 ESTIMATES OF WORKING COSTS FOR (I) A 2000 H. P. POWER GAS INSTALLATION, (II) A 4500 K. W. PRODUCER GAS PLANT, AND (III) A PRODUCER GAS PLANT FOR CONTINUOUS GASIFICATION OF 500 TONS OF COAL DAILY

| CONDITIONS — Load Conditions of Plant | I Power | II Power | III Heating |
|---|---|---|---|
| Hours of full load per annum | 4000 | 8500 | 8760 |
| Size of plant in h.h.p. or kw. or long tons of coal per day | 2000 h.h.p. (1350 kw.) | 6600 h.h.p. (4500 kw.) | 500 tons |
| Cost of coal in dollars per short ton | 2 | 1 | 2 |
| Heating value of coal in B.t.u. per lb | 12,600 | 12,600 | 12,600 |
| Nitrogen content of coal in per cent | 1.3 | 1.3 | 1.3 |
| Cost of sulphuric acid (140 deg. Twaddell) in dollars per short ton | 9 | 9 | 9 |
| Value of sulphate of ammonia in dollars per short ton | 55 | 55 | 55 |
| Value of tar in dollars per short ton | 5 | 5 | 5 |
| Heat consumption of gas engines in B.t.u. per kw-hr | 14,900 | 14,300 | ... |
| **COST OF PLANT** | | | |
| Producer power gas and ammonia recovery plant (Lymn System) in dollars | 40,600 | 126,500 | 605,000 |
| Buildings and foundations for same | 4400 | 12,000 | 55,000 |
| Complete gas engine installation consisting of gas engines, dynamos, all auxiliary machines, exhaust boilers, overhead crane, etc., in dollars | 88,000 | 335,500 (spare set of 2250 kw.) | ... |
| Buildings and foundations in dollars | 13,000 | 48,000 | ... |
| Total Cost of Installation | 138,000 | 522,000 | 660,000 |
| **WORKING DATA** | | | |
| Amount of kw-hr. per annum | 5,400.000 | 38,250.000 | ... |
| Tons of coal used (including stand-by losses) per annum | 4830 | 29,840 | 204,400 |
| Tons of sulphate of ammonia recovered per annum | 206 | 1346 | 9210 |
| Tons of tar recovered per annum | 230 | 1500 | 10,500 |
| Tons of sulphuric acid consumed per annum | 190 | 1280 | 8800 |
| Rate of amortization on machines and plant in per cent per annum | 12 | 12 | 12 |
| Rate of amortization on buildings and foundations in per cent per annum | 6 | 6 | 6 |

| | I Power | II Power | III Heating |
|---|---|---|---|
| **ANNUAL WORKING COSTS IN DOLLARS OF PRODUCER GAS AND AMMONIA RECOVERY PLANT (LYMN SYSTEM)** | | | |
| Cost of coal | 9660 | 29,840 | 408,800 |
| Labor | 5600 | 16,630 | 49,500 |
| Repairs and maintenance | 1230 | 3780 | 18,000 |
| Oil, waste, lighting, etc | 680 | 2990 | 15,330 |
| Sulphuric acid | 1710 | 11,520 | 79,200 |
| Depreciation and interest | 5132 | 15,900 | 75,900 |
| Total debit | 24,012 | 80,560 | 646,730 |
| Credit by sulphate of ammonia | 11,330 | 74,030 | 506,550 |
| Credit by tar | 1150 | 7500 | 52,500 |
| Total credit | 12,480 | 81,530 | 559,050 |
| Total annual cost of gas | 11,012 | 970 Profit | 87,680 |
| Cost of gas in cents per 1000 cu. ft. (heating value 150 B.t.u. per cu. ft. net) | 2.10 | 0.03 | 0.32 |

| ANNUAL WORKING COSTS OF GAS ENGINE PLANT (Based upon first class German Gas Engine practice) | Dollars per Annum | Dollars per Annum |
|---|---|---|
| Cost of gas as above | 11,012 | 970 Profit |
| Repairs | 1250 | 5170 |
| Oil, waste, water | 840 | 4420 |
| Labor at American rates | 3590 | 10,370 |
| Depreciation and interest | 10,380 | 3180 |
| Total costs | 27,072 | 62,170 |
| Total cost of power in cents per kw-hr | 0.50 | 0.16 |
| Total cost of power in dollars per kw-year | .... | 13.80 |
| Total cost of power in dollars per h.p.-year | .... | 10.30 |

These modifications are to provide a vastly increased volume of air and steam, a deeper fuel bed, superheating of the blast of air and steam, increased pressure of the air blast and consequently deeper water lute, etc. Plants on this system have been built by the Badische Anilin und Soda-Fabrik, of Ludwigshafen (Fig. 18), and by the German Government at Heinitz (Fig. 19). Several others are under construction. These represent the latest type of Lymn plant adopted in large scale practice.

The plants in operation have worked well and a resumé of the operating results of one plant is given in Table A. These results are taken from the daily log sheets of a plant now gasifying about 80 tons of coal per 24 hours, the gas being used for driving four 1300 h.p. gas engine electric sets and also for firing furnaces. The coal in use is common slack and brown-coal at an average price of 12 to 13 shillings per ton. The heating value of the coal is 10,400 B.t.u. per lb. (6000 kg. cal. per kg.) and the nitrogen contained in the coal averages 0.80 per cent. These records cover two periods of four weeks, each being selected quite haphazard. In spite of the high cost and low nitrogen content of the coal, the cost of gas per kw-hr worked out at only 0.55 pfg. or 0.13 cents, is an interesting result.

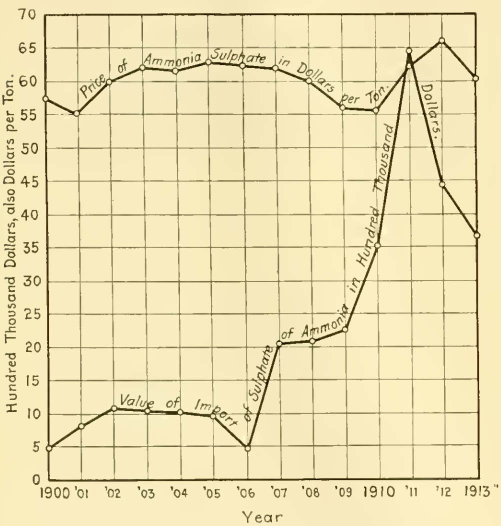



FIG. 21 VALUE OF U. S. IMPORTS AND PRICE FLUCTUATIONS OF AMMONIUM SULPHATE 1900–1913

There is one point in connection with this industry which I think deserves considerable attention. It is well known that the amount of steam generally used in these plants with normal coal is approximately 2½ tons for every ton of coal gasified. Of this amount, up to two-fifths is recovered from the heat of the gases (i.e., during the gas cooling and air saturating cycle of operations) in a modern and properly designed plant. The remainder, 1½ tons, has, however, to be made by direct coal-fired boilers or other means. Needless to say the provision of separate boilers involves a considerable charge on the operating costs of the plant, and it should therefore always be one's endeavor to obtain as large a quantity of steam as possible in the form of waste steam at practically atmospheric pressure (which is quite sufficient) or to raise such steam by utilizing waste heat.

In connection with gas power plants, the steam can be made by utilizing the heat of the exhaust gases from the gas engines. This is a problem to which the author has devoted considerable attention, and in the plant referred to above, all the steam is produced in special boilers of his own design which are heated by the exhaust from the gas engines. In this particular installation there are four boilers, each attached to a 1300 h.p. gas engine, and each raising 2 to 3 lb. of steam per h.p.-hr. This amount of steam is 25 per cent more than that required for the gasification of the coal.

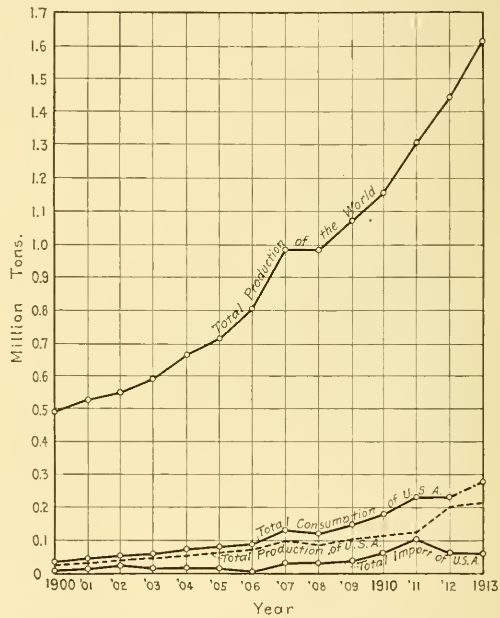



FIG. 22 TOTAL PRODUCTION OF AMMONIUM SULPHATE AND CONSUMPTION IN THE UNITED STATES

It may be suggested that when boilers are utilized for this purpose there is danger of corrosion, but four years' full-time operation is sufficient criterion that this is not so. The writer's experience is that satisfactory operation is merely a question of properly dimensioning the boilers.

The above mentioned plant is the first in the world to be absolutely self-contained as far as steam is concerned and great strides are now being made in the Lymn plants in the matter of utilizing the heat of waste gases from all kinds of operations for the production of steam.

It might be of interest here to give some particulars of the largest gas engines, just ordered from Messrs. Ehrhardt and Sehmer by the Farbwerke Hoechst, Main, which will be coupled to a Lymn plant consisting of five producers. The three engines are each of 4500 h.p., run at 94 r.p.m., and have only two cylinders, each of 1330 mm (4 ft. 4½ in.) diameter and 1400 mm (4 ft. 7 in.) stroke.

In regard to the utilization of the gas for steam rais-

ing purposes there is a great deal to be said, but it will merely be mentioned that the efficiencies which may be realized in well-constructed plants are from 70 per cent upwards (indeed in the Bone system efficiencies of 90 per cent or more have been actually achieved in the writer's presence). Considerable development in this direction of high efficiencies of gas-fired boilers is looked forward to, and the writer has applied in most countries for patents on a different system for achieving similar results to Bone.

At all events, it is important to realize that where coal is expensive gas engines are obviously the more economical to adopt, and where coal is cheap the by-products more than pay for the coal and the gas can be made for nothing or even at a profit. In the latter case, it does not matter very much what quantities of gas are used per h.p., and under such circumstances gas-fired steam plants become as profitable as gas engine plants or more so.

To give a general idea of the adaptability of ammonia recovery plants for power as well as for heating purposes, three estimates of working costs have been made for (I) a 2000 h.p. power gas installation, coupled together with gas engines and working 4000 hr. per annum, (II) a 4500 k.w. producer gas plant, coupled together with gas engines and dynamos furnishing current for say electrochemical purposes, working 8500 hr. per annum, and erected near a colliery where the coal will be cheap, and (III) a producer gas plant for a daily and continuous gasification of 500 tons of coal, the gas being used say for firing steel furnaces. The estimates are given in Table B. The working costs of these three plants are based upon the actual results in practice referred to above. It has been assumed that the cost of labor is 50 per cent and the cost of apparatus is 25 per cent more than in England and Germany.

It will be realized that for industries such as electrochemical plants requiring a large amount of power, it is quite unnecessary to have recourse to water powers which are almost invariably situated in localities quite unsuitable as manufacturing sites and which therefore require long, costly and unreliable transmission systems subject to the dangers of sleet, wind and electrical failures. Every power user who depends upon an uninterrupted supply of current for the success of his operations would gladly dispense with this transmission, even were its high cost of no importance.

In considering the development of ammonia recovery plants, the statements made so far have referred to the treatment of coal, which is obviously the most used combustible. They may also be taken, however, as applying to waste coal containing a high percentage of ash, as well as to other poor grade coals, such as lignite, coke breeze, etc.

Coke breeze, as obtained in the manufacture of lighting gas, has now a particularly advantageous application in these plants. It is well known that as a general rule the retorts in gas works are heated by means of good trade coke which has a high selling value, but the coke breeze which is sieved out is practically a waste product. This substance can now be dealt with, producing all the gas for firing the retorts together with about 60 lb. (value $1.20) of sulphate of ammonia per ton of breeze. Furthermore, much good coke is thus set free for sale to the public at a high value. A large plant is already operating on these lines in England and is very successful and profitable.

There are, however, other combustibles whose use in producer plants is restricted on account of the high percentage of water they contain. Such in particular are peat and wet brown-coal.

The writer, as technical manager to The Power-Gas Corporation was able to apply successfully the Mond Gas process to the treatment of peat between 1904 and 1907. The drying of peat is a most difficult matter and in view of this fact it is interesting to note that today it is possible to produce regularly power gas and by-products from peat containing up to 60 per cent water. This peat can be obtained by relatively short periods of drying in the atmosphere in practically all countries. Evidences of success in this matter are the facts that a 20-ton plant was erected in Germany, some years ago to demonstrate the advantages of this process, and another plant (Fig. 20) dealing with 100 tons of peat per day and producing sulphate of ammonia and power gas has been in operation in Northern Italy for about three years. In the latter case a further peat bog has now been purchased and a second and larger plant built upon it. The writer, too, has entered into a contract for building in Russia a plant of this type to treat 90 tons of peat (stated as theoretically dry) per 24 hr.

The quantity of ammonium sulphate produced per ton of peat depends upon the nitrogen content and varies between 70 and 220 lb. per ton of dry peat gasified. Where peat with about 2 per cent nitrogen is available, one can obtain a large profit simply from the ammonium sulphate, regarding the gases as a by-product. Indeed, with peat which contains

TABLE 3 THE NITROGEN CONTENT OF AMERICAN COALS

| State | Amount of coal samples analysed for nitrogen content | Average content of nitrogen in per cent on theoretically dry fuel |
|---|---|---|
| Alabama | 37 | 1.42 |
| Alaska | 45 | 1.14 |
| Arizona | 1 | 1.25 |
| Arkansas | 18 | 1.41 |
| California | 4 | 0.97 |
| Colorado | 176 | 1.36 |
| Georgia | 1 | 1.13 |
| Illinois | 67 | 1.28 |
| Indiana | 23 | 1.27 |
| Iowa | 15 | 1.16 |
| Kansas | 30 | 1.24 |
| Kentucky | 22 | 1.42 |
| Maryland | 15 | 1.71 |
| Michigan | 2 | 1.38 |
| Missouri | 40 | 1.11 |
| Montana | 81 | 1.03 |
| New Mexico | 27 | 1.29 |
| North Dakota | 6 | 1.15 |
| Ohio | 15 | 1.30 |
| Oklahoma | 20 | 1.63 |
| Oregon | 1 | 1.42 |
| Pennsylvania | 106 | 1.28 |
| Rhode Island | 10 | 0.19 |
| Tennessee | 15 | 1.46 |
| Texas | 5 | 1.16 |
| Utah | 32 | 1.11 |
| Virginia | 27 | 1.29 |
| Washington | 169 | 1.58 |
| West Virginia | 265 | 1.37 |
| Wyoming | 192 | 1.30 |
| Total | 1467 | ... |
| Average | ... | 1.325 |

little nitrogen, gas can in most cases be produced without cost. Other by-products which can be produced from peat are tar (which contains much paraffin), also acetate of lime, etc.

The application of the Mond process to peat as worked out in England has at times been erroneously referred to as the Frank-Caro process. As a matter of fact, however, only one plant was built according to Frank and Caro's designs. This was at Osnabruck, Germany, and it was shut down after twelve months' operation.

In conclusion, the By-Product Producer Gas industry has not been exploited to the same extent in the United States as in Europe, and one object of this paper has been to bring before the engineers of this country the facts relating to an established industry the great advantages of which are at their disposal. These advantages are well recognized in Europe and in other parts of the world and it seems almost an irony of fate that the United States has benefited so little from them.

The author's long experience in Great Britain, Germany and other countries with many kinds of fuel, from peat to brown-coal and from anthracite to the most bituminous coals, does not, however, lead him to dogmatize upon the utilization of the vast range of fuels in this country in plants which have so far been used almost entirely elsewhere. Indeed he is well aware that mistakes have been made in this country in the past by adopting *en bloc* European designs. It might be of interest to know that a plant of his design already modified to suit the local conditions is now being extensively experimented with at an important colliery in the Pittsburgh region and trials on a large scale of all qualities of coals, from waste roof coal upwards, are now being very thoroughly carried out in a Lymn Plant under the direction of Lewis A. Riley, 2d, member of the Society.

About fifty By-Product Producer Gas Plants are already built having a yearly fuel capacity of approximately 2,000,000 tons. These are distributed among Great Britain (which has most of them), Germany, Italy, Spain, China, Japan and this country. The total yearly fuel capacity of them all is close upon two million tons. The gas from them is being used not only for power production but also for all kinds of industrial heating operations, such as reheating furnaces, forging furnaces, annealing furnaces, steel furnaces, core stoves, crucible heating, galvanizing baths, gas works retort firing, spelter furnaces, glass works operations, evaporating brine, calcining operations, roasting operations, distilling operations, heating drying rooms, etc.

It may be contended by many that the adoption of a large number of ammonia recovery plants would run down the sulphate of ammonia market, but it must be borne in mind that in England, where by-product producer gas plants have made more progress than in all other countries together, the proportion of sulphate of ammonia made by this means amounts to only 13 per cent. The remainder comes from lighting gas plants and coke ovens which in Germany, and also to a great extent in England, are producing nearly as much sulphate of ammonia as is possible.

The consumption of sulphate of ammonia is steadily on the increase, although the market has fluctuated considerably during the past year. This substance must therefore be supplied from other sources than those which have so largely supplied it up to now. The author has personally considered this question somewhat closely with reference to the production of nitrogenous fertilizers and is convinced that there is room for a very large increase in the production of sulphate of ammonia from gas producer plants, in spite of the increasing production of synthetic nitrogenous fertilizers.

In this connection Figs. 21 and 22, showing the imports and price fluctuations as well as the comparative production of ammonium sulphate in this country over the period from 1900 to 1913, might be of interest. In considering these data it should be borne in mind that the quantities represented form only a part of the whole nitrogenous fertilizer trade, which comprises, in addition to ammonium sulphate, nitrate of soda, calcium cyanamide, nitrate of lime, guano and animal waste generally.

Regarding the nitrogen content of American coals, Table C represents the average of some 1500 analyses made by that thorough body of workers, the Department of Mines of the U. S. Geological Survey. More than 560 million tons of coal per annum, containing on an average about 1.3 per cent nitrogen, are produced in this country. Imagine this quantity of coal being converted into producer gas and the ammonia recovered from the whole of it, and deduct the amount of sulphate of ammonia which is already produced. The remarkable result is arrived at that about 25 million tons of sulphate of ammonia, having a value of 600 million dollars, are wasted per annum. Surely it is worth while to consider recovering at all events a small portion of this, especially when it is realized that every dollar spent by agriculturists in sulphate of ammonia means crops.

# MODERN STEELS AND THEIR HEAT TREATMENT

BY ROBERT R. ABBOTT,[1] CLEVELAND, OHIO.

Non-Member.

STEEL is an alloy. In its most simple form it is made up of two components: iron and a carbide of iron technically known as cementite. Commercial steel always has at least four other elements present: phosphorus, sulphur, manganese, and silicon, but the total amount of these four elements contained in an ordinary commercial steel is less than 1 per cent, and the influence of the average variation in all of these impurities upon the physical properties of the steel, is slight compared with the effect of the carbon.

The carbon is the main factor in influencing variations in the physical properties. It varies from practically nothing in wrought iron to about 1½ per cent in high carbon tool steel. A variation of 0.1 of 1 per cent of carbon will affect the tensile strength of annealed steel about 8000 lb. per sq. in. The carbon exists as cementite, which is fifteen times as heavy as the carbon of which it is composed. In steel this cementite occurs intimately mixed with about 6½ times its own weight of iron. One part of carbon, therefore, makes up about 112½ parts of this mixture, which is known as pearlite. A steel containing 0.1 per cent carbon is really composed of about 11 per cent pearlite and 89 per cent of iron.

A sample of iron, magnified to 150 diameters, shows about 0.01 per cent carbon, which makes the structure 1 per cent pearlite and 99 per cent iron. This pearlite is not visible under this magnification, and, therefore, the material has the appearance of pure iron. As the carbon increases the pearlite areas become larger and the amount of iron smaller. A microscopic photograph of a steel containing 0.20 per cent carbon shows about 22 per cent pearlite.

Another sample with a still further increase in carbon to 0.40 per cent shows 45 per cent pearlite and 55 per cent iron. Similarly, an 0.80 per cent carbon steel, contains 90 per cent pearlite and 10 per cent iron, while in a 0.90 per cent carbon there is no excess iron and, therefore, 100 per cent pearlite.

As the carbon increases above the point necessary to form 100 per cent pearlite it must necessarily exist as free cementite, as all the iron has been taken up to form pearlite when the carbon reached 0.90 per cent.

A steel with 1.4 per cent carbon, consists of 92.5 per cent pearlite and 7.5 per cent cementite. A steel containing 2.5 per cent carbon, consists of 24 per cent cementite and 76 per cent pearlite. A steel of this high carbon is rare and has no commercial application. White cast iron, which is the material from which malleable iron is made, is an impure steel of a carbon content similar to this.

Briefly summarizing the structural condition of a series of steels of various carbon contents, we see that one containing 0.9 per cent carbon consists of 100 per cent pearlite. This steel is known as saturated, or, commonly, an eutectoid, steel. A steel containing less than 0.9 per cent carbon contains pearlite and iron. It is known as an undersaturated or hypo-eutectoid steel. A steel with more than 0.9 per cent carbon is known as super-saturated or hyper-eutectoid steel; it contains pearlite and cementite.

When a piece of steel is pulled apart in a tensile machine the cross-sectional area at the point of fracture is less than that of the original bar. The amount of this difference is known as the "reduction in area," and it is a fair measure of the toughness of the steel. While the meaning of the term "toughness" is open to more or less dispute, we can consider it as the ability of the metal to distort without causing fracture. For example, a steel which can be bent through an angle of 75 deg. before fracture is tougher than one which can be bent only 25 deg.

If tensile tests are made on a series of steels of increasing carbon contents we find that the tensile strength increases with the increase in the amount of pearlite, but the toughness decreases.

The tensile strength of iron is about 40,000 lb. per sq. in. This can be increased by about 700 lb. for each increase of 1 per cent pearlite. The reduction in area for pure iron is about 80 per cent and this is decreased by about 0.5 per cent for each increase of 1 per cent pearlite. For ordinary structural purposes a steel which is subject to vibration or shock is not safe with much less than 50 per cent reduction in area. From these figures it is readily calculated that a steel with 60 per cent pearlite, which corresponds to about 0.55 per cent carbon, has a reduction in area of about 50 per cent. Such a steel has a strength of approximately 80,000 lb. per sq. in.

Evidently, then, the strength of a steel subjected to dynamic stresses can be safely increased up to 80,000 lb. per sq. in. by the use of an increased carbon content; however, every additional increase in strength is obtained at the expense of the toughness. A further consideration is the fact that the hardness of the steel, and therefore the difficulty and expense of machining, increases with the pearlite.

A little consideration of the above facts will show that they are logical and what should be expected. The pearlite is composed of fine plates of pure iron strengthened and made rigid by cementite, which itself is intensely hard and strong, but very brittle.

The pearlite, as a mass is strong, but, due to the cementite in it, it is not as tough as pure iron. Pure iron compared to pearlite is weak but tough. A combination of the two will give characteristics consistent with the proportion of the constituents.

It is apparent that in order to obtain greater strength on the steel without increasing the amount of pearlite, or, what is the same thing, the amount of carbon, at least three things can be done: (1) increase the strength of the iron, (2) increase the strength of the pearlite, or (3) increase the strength of both. Practically, these are reduced

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[1] The Peerless Motor Car Company.

Abstract of paper presented at a joint meeting of the Philadelphia local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and the Franklin Institute on January 14, 1915. This paper was published in full in the Journal of the Franklin Institute, April, 1915, to whom we are indebted for the use of the illustrations.

to two, because anything which increases the strength of the iron also increases the strength of the pearlite to some extent, because of the iron in it.

This can be accomplished by adding to the steel some element or elements which will alloy with either the iron, the pearlite, or both, and increase their strength. A steel containing this extra element is known as an alloy steel. There are two classes of alloy steels: those in which one or more of the normal impurities are made abnormally large, and those in which one or more elements not normally present are added. To the first class belong silicon and manganese steels. To the second class, which is the more important commercially, belong nickel, chrome, chrome vanadium, chrome nickel, tungsten, and titanium steels.

As typical examples of the two methods of increasing the strength of steel, nickel and chrome steels may be considered. Nickel forms a solution or alloy with the iron

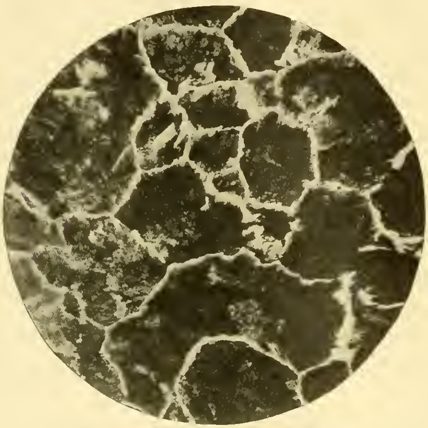


Fig. 1 Structure Showing Cementite and Pearlite, 1.4 per cent Carbon (150 Diameters)

which is stronger than iron alone. Chromium replaces some of the iron of cementite, forming a carbide of chromium. The pearlite thus formed from the double carbide of chromium and iron is stronger and at the same time tougher than ordinary pearlite formed without chromium. The most widely used nickel steel contains $3\frac{1}{2}$ per cent nickel, while the common chrome steel has about 1 per cent chrome. Such a nickel steel will be about 20,000 lb. per sq. in. and chrome steel about 15,000 lb. stronger than a simple steel of the same carbon content. At the same time the toughness of the nickel steel will be about the same as that of a simple steel, while for the chrome steel it will be a little greater. It is apparent, then, that the use of an alloying element to increase the strength of steel is better than to use carbon for the same purpose, as the increased strength is not obtained at the expense of the toughness.

Thus the relation between strength and toughness in ordinary steel can be varied by changing the relative amounts, and also the strength or toughness of two substances composing it; namely, the pearlite and iron. In either case this must be done by adding something to the steel: in the first case, carbon, and, in the second, some alloying element. Can we not change the relative amounts of the elements or their strength by some process of heating?

Consider the steel containing 0.20 per cent carbon, which forms about 22 per cent pearlite. If we heat this to a temperature of 1000 deg. fahr. and suddenly cool or quench it in cold water, it will be found that neither its physical properties nor its appearance under the microscope has been changed; if the temperature is increased to 1100 deg., still no change is found; nor will any difference be detected until a temperature of about 1375 deg. fahr. is reached, when it will be found that the iron is still present and in about the same amount, but the pearlite areas have become more or less rounded. If examined under 1200 diameters, it will be found that the white areas are the iron, while the dark areas represent what was originally pearlite; it has now apparently coalesced, so that the original cementite and ferrite of which it was composed have merged into a single substance.

The real explanation of the change which has taken place is that the iron which originally composed part of the pearlite underwent an allotropic change at this temperature, and in its new form it is capable of dissolving to a solid solution the cementite with which it was in contact. This new solid solution is known as austenite, and by the sudden quenching, time is not given for the reverse allotropic change to occur completely. It cannot be entirely prevented, and the transition substance which we really obtain is known as martensite.

A steel thus treated is different from the untreated steel in one of its constituents, and is made up of iron and martensite instead of iron and pearlite. Martensite is much stronger but more brittle than pearlite. We should then expect that our treated steel should be stronger but less tough than the one not treated. The untreated steel has a tensile strength of about 55,000 lb. per sq. in., and a reduction in area of 65 per cent. The same steel heat treated as just explained has a tensile strength of about 95,000 lb. per sq. in., and a reduction in area of about 30 per cent. These properties are very similar to those of a high carbon steel containing about 100 per cent pearlite or 0.90 per cent carbon. In other words, by a simple process of heat treatment, we can obtain with a 0.20 per cent carbon steel the physical strength of a 0.90 per cent carbon untreated steel.

If at some definite temperature the pure iron in the pearlite went into a solid solution with the cementite, possibly at a still higher temperature, more of the iron could be caused to go into such a solution. A photograph of the structure of the same steel quenched from 1440 deg. will show that the iron has decreased in amount, while the martensite has increased. Apparently then, as the temperature is raised, the saturation point of the martensite for iron is increased; just as in a water solution more sugar can be caused to dissolve by increasing the temperature.

At a temperature of 1565 deg., all of the iron will go into solution and the quenched steel will consist of 100 per cent martensite. A high magnification (1200 diameters), shows the martensite structure to be triangular. Thus, it is seen that as the steel is subjected to an increasing temperature of quenching, the amount of iron constantly decreases until

it becomes zero, while with the increase of carbon, the pearlite increases to 100 per cent and with the increase of temperature, the martensite increases to 100 per cent.

With the increase of temperature, the strength increases, beginning with the temperature of the first change, until final absorption of the iron, while the toughness also increases if the carbon is low. Table 1 illustrates this more fully:

Table 1. Variations in Strength and Toughness in Untreated and Heat-Treated Steels

| Untreated steel | | | Heat-treated steel, 0.20 per cent carbon | | |
|---|---|---|---|---|---|
| Per cent pearlite | Strength | Toughness | Per cent martensite | Strength | Toughness |
| 25 | 55,000 | 65 | 25 | 95,000 | 30 |
| 50 | 75,000 | 55 | 50 | 98,000 | 40 |
| 75 | 90,000 | 45 | 75 | 100,000 | 50 |
| 100 | 105,000 | 35 | 100 | 105,000 | 55 |

The temperature at which the pearlite first changes is known as the lower critical temperature, and the temperature at which the absorption of iron is complete is known as the upper critical temperature. It is apparent that of two steels containing different percentages of carbon, and therefore different percentages of pearlite, the one containing the more pearlite will have less iron to dissolve, and therefore the temperature of final absorption will be lower. In other words, the upper critical temperature is lowered by an increase in the carbon content. If the steel is all pearlite, *i.e.,* contains 0.90 per cent carbon, its upper and lower critical temperatures will coincide.

With some steels the best results are obtained by quenching just at the absorption point, while with others a higher temperature is necessary. The metallurgist must know the amount of this variation for different types of steels.

The heat treatment of an alloy steel is exactly the same in principle as that explained above for plain carbon steels, the alloying elements giving increased strength as well as increased toughness to the heat treated, in the same manner as it did in the untreated steel.

From the foregoing, it is apparent that a steel heat-treated to bring out high strength, will consist of 100 per cent martensite, no matter what amount of carbon there was originally present, or whether alloying elements were there or not. Evidently then, martensite will have a varying composition. Under the microscope there is very little difference in appearance, no matter what the composition. Since martensite is really formed from a solution of cementite in iron, a high-carbon steel will form a stronger solution than a low-carbon one, just as a strong or weak solution of salt can be had in water. Alloying elements in the martensite do not cause any difference in its structure any more than a little sugar would cause a difference in the appearance of a salt-water solution. These alloying elements, however, have a very decided influence upon the position of the critical temperature; for example, 0.1 per cent manganese lowers the upper critical temperature 6 deg., while it has practically no effect upon the lower critical temperature; 0.1 per cent chromium raises the lower critical temperature 4 deg. when nickel is absent, but with nickel present it raises it only 3 deg., but in neither case does it have any appreciable influence upon the upper critical temperature. The business of the metallurgical engineer is to know absolutely the influence of all elements upon these critical temperatures.

In general, these martensites made from a steel containing more than 0.2 per cent carbon have not enough toughness for their strength, and to remedy this, the steel is given a second low heat, commercially known as a drawing heat, which allows a certain amount of transformation to take place in the martensite, and reduces its strength but increases its toughness. By varying the final heat, an unlimited number of combinations of strength and toughness are available. As the drawing temperature is raised still higher the micro-structure of the steel becomes extremely fine and it is known as sorbite. This is really an imperfect pearlite intimately mixed with iron.

Broadly summarized, the process of heat treatment consists in transforming an alloy from a mechanical mixture of two substances into a homogeneous solution of a single substance. This very fact gives to a heat-treated steel one of its most valuable advantages over the untreated steel; namely, its ability to withstand repeated shocks or vibrations, or, as it is popularly expressed, "fatigue-resisting power." The reason is obvious: an alloy composed of two dissimilar substances has mechanical boundaries between them. This fact is a source of weakness under repeated stresses, the reasons for which are more or less complicated. An untreated steel contains these boundaries; a correctly heat-treated steel does not.

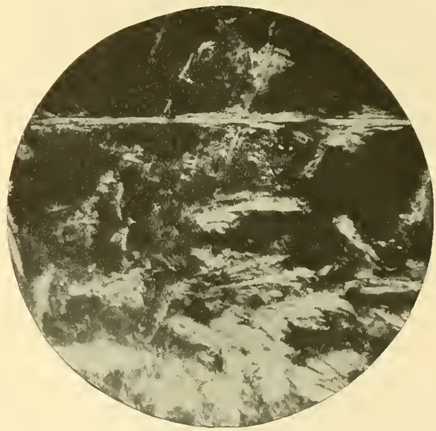


Fig. 2 Structure Showing Cementite Needles (350 Diameters)

There is a still further advantage based upon a different consideration. A steel with a tensile strength of, say, 60,000 lb. per sq. in., if subjected to repeated reversals of stress of any magnitude, will finally break after a definite number of these reversals; as the magnitude of these stresses approaches the actual strength of the steel, the number of reversals necessary to cause a break rapidly decreases; as a consequence of this fact, a comparatively slight increase in the strength of a piece of steel will increase way out of proportion its resistance to fatigue break. Therefore, it is frequently desirable to heat-treat a piece of steel to give it

an added factor of safety under shock or alternate stresses, even though its static factor of safety is sample.

In supersaturated steels,—that is, those containing more than 0.90 per cent carbon, we have present cementite and pearlite. Most tool steels belong to this class. In the heat treatment of such a steel, the pearlite changes to austenite at the same temperature which we found for an undersaturated steel. As the temperature is raised above this point, the excess cementite begins dissolving into this austenite, just as the iron did in a lower carbon steel, until at a definite temperature all of it is dissolved, and we have, as before, austenite. The cementite is more sluggish in dis-

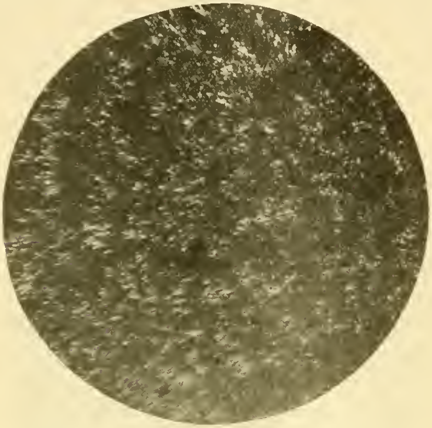


Fig. 3 Structure Showing Cementite Globules (350 Diameters)

solving into the austenite than the iron, and the reaction requires more time to complete. As we have previously seen, cementite is extremely brittle and hard; it occurs usually as sheets in the pearlite or thin envelopes surrounding grains of pearlite. These two types are shown in Fig. 1 (150 diameters) and Fig. 2 (350 diameters). A piece of tool steel which has been previously slowly cooled from above the temperature at which the last of the cementite went into solution will contain the cementite in one of these two forms. If it is hardened at the lowest possible temperature its pearlite will be changed to martensite, while its cementite will be unchanged. These sheets or envelopes of cementite will cause the steel to be extremely brittle, and is a source of many of the troubles of the steel user.

Now if the steel is quenched from above the upper absorption point this cementite will be gotten rid of, but the steel is somewhat softer because of its absence. The structure of the steel has also been coarsened by the high temperature, which causes it to be brittle. If the coarsened steel is again reheated slightly above the lowest hardening temperature, the cementite will be precipitated out of the solution, but, instead of being in sheets or plates, it will occur as fine dots, which give extremely good wear and have practically no effect of brittleness. A steel thus treated is shown in Fig. 3 (350 diameters). This same arrangement of cementite can be formed by heating the steel to just above the lowest hardening temperature and holding at this temperature for some time.

In an alloy steel the influence of carbon is reduced, and this reduction is greater the higher the percentage of alloy. For structural purposes the carbon of alloy steels rarely exceeds 0.50 per cent; those containing less than 0.25 per cent are usually used for parts which are to be surface-hardened by the carbonizing process, and above 0.25 per cent for parts which are to be subjected to stresses which do not require a hardened surface.

In the carbonizing process the outer surface of a low-carbon steel has its carbon content raised by heating in contact with carbonaceous material. The depth of penetration of this high-carbon shell and also the percentage of carbon it contains are functions of the carbonizing material used and the temperature and time of carbonization in general; the outer surface should be a supersaturated steel, and therefore its treatment comes under that of tool steel, which we have just considered.

To produce a correctly heat-treated, carbonized article we have four functions to consider: (1) the chemical analysis of the steel; (2) the carbonizing material; (3) the time of carbonization, and (4) the temperature of carbonization. These should be adjusted so that the upper absorption point of the iron of the core shall exceed that of the cementite of

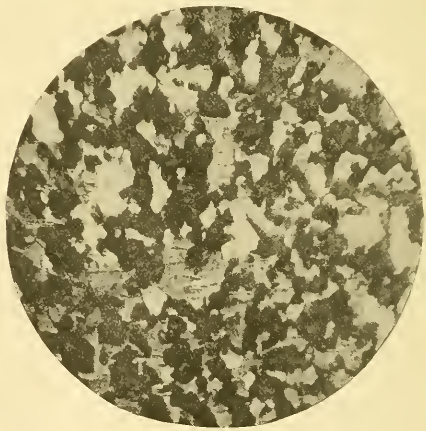


Fig. 4 Core of Carbonized Steel, Single Quench (150 Diameters)

the case. Under these conditions, if the steel is quenched from above the absorption point of the core, this will be entirely martensitic, and at the same time the cementite sheet or net of the case will be absorbed, so that it will also be martensitic.

Now in order to obtain the maximum hardness on the surface this cementite must be precipitated, as shown in Fig 3, by a low quench from the hardening temperature. During this second quench the iron of the core will also be precipitated out in practically the same globular form, with this difference; there being more excess iron than excess cementite in the core, the iron will precipitate in larger particles and will not have the characteristic globular appearance.

A comparison of the difference in structure of the core of a piece of carbonized steel with a single hardening heat and this double refining and hardening heat is shown in Figs. 4 and 5. In both cases we have the same amount of martensite (black) and iron (white) present, but the mixture is much more intimate and fine in Fig. 5 (double quench). This increases enormously the toughness of the finished steel.

## DISCUSSION

H. V. Wille. The theory of heat treatment has been understood by metallurgists for many years, but this has been largely applied in a practical way only during recent years. Some years ago Dr. Sargeant, who is now connected with the Crucible Steel Company of America, exhibited a small experiment at the Franklin Institute which showed in an interesting way the basis of all heat treatment of steel. He heated in a flame of a Bunsen burner a thin plate until he obtained a red spot. Upon removal from the flame he showed that this spot gradually decreased in brightness until a certain temperature was reached, whereupon the fall of the temperature was arrested and the spot glowed with a marked increase in luminosity, showing that some internal change had taken place in the molecular structure in the steel which caused the elevation in temperature in a manner similar to that produced by the combination of sulphuric acid and water.

If the steel is quenched at this temperature, it will retain its molecular structure, and if examined it will be found that steel so quenched is of maximum hardness, with a less loss of ductility for that particular grade. Furthermore, the molecular structure will not be changed unless the steel is again heated above this critical or recallescence point. It follows therefore that a steel so quenched can be annealed below this temperature without change in the molecular structure, but with a great increase in ductility. A steel so treated has a much higher elastic limit and a much greater reduction of area than steel which has been subject to the ordinary annealing process. The sole advantage of all of the modern high-grade steel consists solely in an increase in the elastic limit, so that the designer is enabled to reduce the weight or size of any detail by the use of a higher unit stress, or to increase the factor of safety by the retention of the same unit stress as in a straight annealed steel.

Extremely high elastic limits can be obtained by the use of the various alloys to assist the hardening effect of carbon, such as nickel and chromium, or of the various tertiary alloys, such as chrome nickel, chrome vanadium, or chrome titanium. Steel can be produced having an elastic limit of 150,000 lb. with sufficient ductility to prevent failure by shock by the use of some of these alloys with proper heat treatment, so that engineers are able to design parts with unit stress as high as 100,000 lb. per sq. in. in place of about 20,000 lb. per sq. in for a straight carbon annealed steel. It is hard to grasp the great benefits derived from this enormous increase in the elastic limit.

I do not, however, feel that the possibilities of the use of straight carbon, heat-treated steel have been utilized to the fullest extent. This condition results from the fact that metallurgists write the specifications to which steel is purchased, and the chief object of the metallurgist is to secure a steel of maximum ductility. The designing engineer, however, is not concerned about the ductility of the steel, but desires a steel having a maximum elastic limit; the manufacturer is unable to produce this steel for the designer because of the ductility requirements in the specification.

Mr. James E. Howard made extensive experiments on tests on rotating shafts. These results showed that the high-carbon, heat-treated steel withstood as many rotations as the more ductile alloy steel, so that it would appear that equally good results could be obtained by the use of the cheaper high-carbon, heat-treated steel as is obtained from the use of the more expensive and more ductile alloy steel. These views seem to be borne out both by the experience of automobile builders and of the railroads. I recall going through the principal automobile factories in France, about

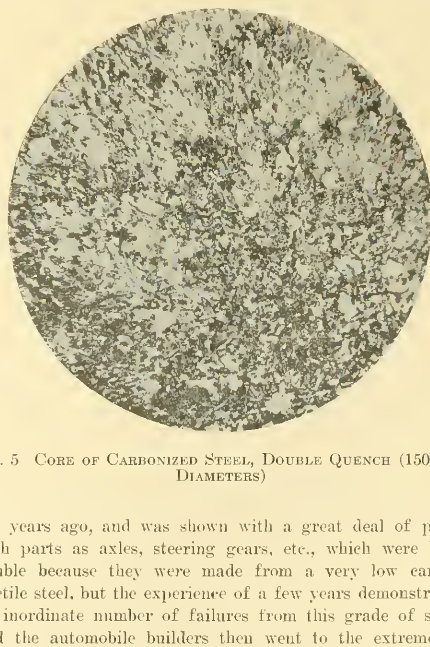


Fig. 5 Core of Carbonized Steel, Double Quench (150 Diameters)

ten years ago, and was shown with a great deal of pride such parts as axles, steering gears, etc., which were bent double because they were made from a very low carbon ductile steel, but the experience of a few years demonstrated an inordinate number of failures from this grade of steel, and the automobile builders then went to the extreme of using the extremely high grade alloy steel, which gave better results, notwithstanding the fact that it possessed less ductility than the carbon steel.

The railroads met with the same experience, and the first experiments in the use of steel in substitution for iron were made with low-carbon steel having the same physical properties as wrought iron. A large number of failures followed this substitution, but they were eliminated by the use of steel having a tensile strength of about 80,000 lb. per sq. in. This grade of steel is successfully used in railroad service, and there is a gradual tendency to go to steel of even higher carbon having a tensile strength of about 110,000 lb. per sq. in. Such steels have been used in an experimental way and have fully proved their value in comparison with the higher-priced alloy steels having greater ductility.

# A PROPOSED SYSTEM OF CLASSIFYING AND DIGESTING THE RECORDS OF THE SOCIETY

BY EDWIN J. PRINDLE, NEW YORK CITY

Member of the Society

THE records of the Society contain most valuable information upon every branch of mechanical engineering. They present the results of long experience and deep research of many of the most eminent mechanical engineers in the world. And yet I venture that after a paper has passed from the memory of those who heard it or read it, and the volume of Transactions or number of The Journal in which it appeared has ceased to be current, it has practically ceased to exist so far as usefully serving the Society.

Suppose, for instance, an engineer is at work upon some problem involving a detail of boiler practice. There are probably one or more articles upon the general subject of boiler practice in every one of the thirty-five volumes of Transactions of the Society. His detail of boiler practice may have been treated from several points of view, and if he could readily turn to the volume and page where each particular view of his subject is to be found, he might be led immediately to the solution of the problem. The only way, however, in which he can make certain whether or not his topic has been treated in the records is to go over patiently every page of every paper dealing with boiler practice and the entire discussion of each of these papers, and when he has finished, he may find as a reward for his labors, that the point has never been presented. The extent of the labor and the uncertainty of the result will often cause him not to search the records of the Society at all, but to try to solve the problem himself in the hope that he may reach a solution in less time than the perhaps fruitless search would take.

Clearly, any plan which would enable one to turn immediately to all the information which the Society's records contain upon a particular branch or point of a general subject, would be of the greatest advantage to the practicing engineer, and would save from comparative oblivion the fruits of much brilliant and arduous labor represented in papers in the past Transactions and Journals of the Society.

My suggestion to the Society, consists essentially in adapting to its records, methods of classifying, indexing and digesting, with which I have come in contact in the practice of the law, aided in its application to the records of this Society by the experience of the United States Patent Office in classifying inventions in general, and particularly mechanical inventions.

Until comparatively recent years the "Digests" of volumes of legal decisions have been published in book form, and I here present a portion of the index of such a Digest, under the title "Patents" (Fig. 1).

In order to illustrate the advantage of a system which will bring together the reasoning of several articles on the same general subject, I will show how this particular section of the digest is used. We will suppose that in a patent suit the question arises whether or not the thing shown in the patent amounts to an invention and the bearing on that question of the fact that the sales of the patented article have been large. The point is one which may have

**PATENTS**

I. SUBJECTS OF PATENTS.
§ 1. Nature of patent rights.
§ 4. Arts.
§ 6. —— Principles or laws of nature.
§ 7. —— Process or methods.
§15. Designs.

II. PATENTABILITY.

(A) *Invention.*
§ 16. Nature of patentable invention.
§ 17. Nature and degree of skill involved.
§ 19. Enlargement or change in degree.
§ 20. Change of form.
§ 21. Substitution of materials.
§ 22. Substitution of mechanical equivalents.
§ 25. Aggregation.
§ 26. Combination.
§ 27. Application to new use.
§ 28. Designs.
§ 30. Reduction to practical use or operation.
§ 31. Evidence of invention.
§ 32. —— Presumptions and burden of proof.
§ 35. —— Utility and extent of use.
§ 36. —— Weight and sufficiency.

(B) *Novelty.*
§ 37. Nature of patentable novelty.
§ 41. New Combination.
§ 42. Production of new or improved result.
§ 44. Knowledge of inventor.
§ 45. Evidence of novelty.

(C) *Utility.*
§ 46. Nature of patentable utility.
§ 49. Evidence of utility.

(D) *Anticipation.*
§ 50. Prior knowledge or use.
§ 51. —— Nature and extent in general.
§ 52. —— Accidental or unintentional production.
§ 53. —— Experiments and incomplete inventions.
§ 54. —— Unsuccessful and abandoned devices.
§ 56. —— Different use or purpose.
§ 57. Evidence of prior knowledge or use.
§ 58. —— Presumptions and burden of proof.
§ 59. —— Admissibility in general.
§ 61. —— Applications for patents.
§ 62. —— Weight and sufficiency.
§ 63. Prior patents.
§ 64. —— Requisites and validity in general.
§ 66. —— Operation and effect.
§ 72. Identity of invention.
§ 73. Priority of anticipation to date of invention.

(E) *Prior Public Use or Sale.*
§ 75. What constitutes public use.
§ 78. Priority and continuance of use or sale.
§ 80. Operation and effect.
§ 81. Evidence of use or sale.

(F) *Abandonment.*
§ 82. What constitutes abandonment in general.
§ 83. Delay in making or prosecuting application for patent.
§ 87. Evidence of abandonment.

III. PERSONS ENTITLED TO PATENTS.
§ 90. Original inventors and priority between inventors.
§ 91. Evidence as to originality and priority.
§ 92. Joint inventors.
§ 93. Employers and workmen.

FIG. 1 PORTION OF TYPICAL INDEX OF A LAW DIGEST

been treated in any one of over five hundred volumes of decisions of the Federal Courts. In eight volumes, the digest from which I have reproduced the index on "Patents" covers all Federal decisions upon all subjects since 1880, which occupy three hundred and twenty-five volumes. The subject of "PATENTS" which is treated in about ten per cent of the decisions, is all found in a single volume of this

Presented at the New York local section of The AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on February 9, 1915.

Digest. Looking at our index of the subject of "PATENTS," the question is one relating to the general subject of the "patentability" of the invention, and to the sub-division thereof of "invention," and it relates to the particular phase of "invention," Evidence of Invention, Sec. 35, Utility and Extent of Use, thus:

"Patentability
  Invention
    Evidence of Invention
      Utility and Extent of Use."

We therefore need to look at Sec. 35 of the subject of "PATENTS." Turning to Sec. 35, we find that it appears as shown in Fig. 2.

Here we find the rulings of four separate courts on cases where the question had been raised whether the thing disclosed in the patent amounted to an invention. The decisions of the Courts (like the papers of our Society) usually contain at least a number of points or subdivisions, each of which may be separately important in the consideration of some particular matter, and therefore each of which points should be the subject of a separate paragraph or syllabus, so that each syllabus can appear in its proper place in the classification of the digest. It would be of interest, therefore, to see how one of the decisions we have been considering is digested.

**§ 35. —— Utility and extent of use.**
See 38 Cent. Dig. Pat. §39.
[a] **(U.S. C.C.A., N.Y.,** 1909)
While commercial success of a patented device may be important on the question of invention and may determine such question, it is not alone sufficient evidence of mental conception, amounting to invention— (C. C.) Fernald v. Oneida Nat. Chuck Co., 167 F. 559, decree affirmed Fernard v. Oneida Nat. Chuck Co., 174 F. 1020, 98 C. C. A. 664.
[b] **(U.S. C.C.A., Ohio,** 1909)
The fact that a patented device overcame defects in prior structures which persons skilled in the art had for several years been trying unsuccessfully to remedy, and went into immediate and successful commercial use, is persuasive evidence of invention.—Electric Controller & Supply Co. v. Westinghouse Electric & Mfg. Co., 171 F. 83, 96 C. C. A. 187.
[c] **(U.S. C.C., N.Y.,** 1908)
The fact that the product of a machine made by a new combination of old elements goes into general use and displaces others is some evidence, of greater or less weight, that the new combination involved invention.—Stafford v. Morris, 161 F. 113.
[d] **(U.S. C.C., Wis.,** 1910)
The great commercial success of a patented device may turn the scale on the question of invention in a doubtful case.—Beckwith v. Malleable Iron Range Co., 174 F. 1001.

Fig. 2 Typical Section of a Law Digest

In Figs. 3 and 3a, are shown the syllabi appearing at the head of the text of the last decision of the group of four we have been considering.

It will be noticed that in the parenthesis in the first line of each syllabus is given the number of the section of the digest in which the syllabus belongs, so that one can readily turn to all other decisions upon the same point, in subsequent volumes of the digest, by looking under the section number. Some digests not only furnish this information, but indicate the page of the decision upon which the point can be found to which the syllabus relates. Decisions are sometimes many pages long, and this device enables one to turn immediately to the part of the decision in which he is interested instead of having to hunt through the entire decision.

This system of indexing and digesting law books is very satisfactory when carefully carried out, except that new volumes of digests have to be published from time to time, as new volumes of decisions are issued (which is constantly being done). This requires either a republishing of the digest to combine several volumes in one, or the consultation of each of the several volumes. Of recent years, a digest covering all the decisions relating to "patents" has been published in card index form, which obviates the difficulties just mentioned as it can be constantly brought up to date by the insertion of new cards.

BECKWITH v. MALLEABLE IRON RANGE CO. 1001

Thus far the process of the patent has been treated as requiring the use of a pinch-cock to close the connection between the lamp and the air pump. The claims are, however, broader than the specifications and drawings, and it is contended that they cover a process wherein the connection is closed by any apparatus which does not necessitate the use of heat. Closure without heat is said to be the process of the present patent; closure with heat, the Maglinani process.

But closure was the essential thing of the Maglinani process. Heat was a mere incident. This incident proved troublesome. What was to be done? As already indicated, I think that mechanical skill should have been quite sufficient to answer this inquiry by pointing out that the difficulties arising from a closure with heat should be remedied by a closure without heat—there being appliances old in the art suitable for making it.

Treating the patent as broad in scope or narrow in scope, it is, in my opinion, void for want of invention. It must be borne in mind that this is not a case where special consideration must be given to a simple expedient because it accomplishes a result long sought for, but never attained. There is nothing in the record to indicate that any one other than the owner of the Maglinani process sought to remedy its deficiencies, and this patent was applied for soon after the Maglinani patent was granted.

In my opinion, the decree of the Circuit Court should be affirmed, with costs.

BECKWITH v. MALLEABLE IRON RANGE CO.

(Circuit Court, E. D. Wisconsin. January 21, 1910.)

1. Patents (§ 165*)—Construction of Claims—Reference to Specification.
While the courts lean toward reading into the claims of a patent such limitations as will save the real invention as disclosed by the specification and the prior art, where claims employ broad and nebulous terms for the apparent purpose of enabling the patentee to monopolize an important industry, the claims will not be narrowed beyond the boundaries clearly warranted by the specification.
[Ed. Note.—For other cases, see Patents, Dec. Dig. § 165.*]

2. Patents (§ 165*)—Construction of Claims—"Convex" Surface.
The word "convex," used in the claims of a patent as applied to a surface, is to be given its generally accepted meaning, ~~as~~ indicating a surface of a more or less spherical form rather than cylindrical.
[Ed. Note.—For other cases, see Patents, Dec. Dig. § 165.*]

3. Patents (§ 35*)—Evidence of Invention—Commercial Success.
The great commercial success of a patented device may turn the scale on the question of invention in a doubtful case.
[Ed. Note.—For other cases, see Patents, Cent. Dig. § 39; Dec. Dig § 35.*
Utility, extent of use and commercial success as evidence of invention, see note to Doig v. Morgan Mach. Co., 59 C. C. A. 620.]

*For other cases see same topic & § NUMBER in Dec. & Am. Digs. 1907 to date, & Rep'r Indexes

Fig. 3 Complete Typical Digest of a Legal Decision

Each guide card of a main class has a number as well as a name, and the numbers, although not consecutive, are in a progressive order. The numbering of these cards progressively fixes the proper position of each one in the digest as a whole. The leaving of unused numbers between the main guide cards is for the purpose of allowing the introduction of new guide cards in their proper intermediate positions as occasion may arise. The main guide cards are numbered successively, and arranged alphabetically, which enables one to find a proper main guide card quickly. The sub-guide cards under each main card are not only arranged alphabetically, but each one is designated by a letter of the alphabet. These successive letters fix the

relative positions of the sub-guide cards in their main class. This arrangement of numbering the main cards and lettering the sub-class cards enables each syllabus card to be correspondingly numbered and lettered so that it can be correctly replaced after it has been used. Further, the syllabus cards in each sub-class are numbered consecutively, so that it can be told whether or not any card is missing, and, if so, what is its number.

It seems clear to me that the general plan of digesting and classifying the separate points or sub-topics in the

1002 174 FEDERAL REPORTER.

4. PATENTS (§ 62*)—SUIT FOR INFRINGEMENT—DEFENSES—BURDEN OF PROOF.
In a suit for infringement of a patent, the burden rests on a defendant to prove the defenses of anticipation or prior use beyond a reasonable doubt.
[Ed. Note.—For other cases, see Patents, Cent. Dig. § 78; Dec. Dig § 62.*]

5. PATENTS (§ 34*)—ANTICIPATION—PRIOR PATENTS.
Where it is sought to show the state of the art by prior patents, nothing can be used except what is disclosed on the face of such patents which cannot be reconstructed in the light of the invention in suit and so used as a part of the prior art.
[Ed. Note.—For other cases, see Patents, Dec. Dig. § 34.*]

6. PATENTS (§ 65*) — ANTICIPATION — ACCIDENTAL FEATURES OF PRIOR STRUCTURES.
The accidental occurrence of an element or feature of a patented combination in prior structures, where its character and function as subsequently used were not recognized, does not constitute an anticipation.
[Ed. Note.—For other cases, see Patents, Cent. Dig. § 80; Dec. Dig. § 65.*]

7. PATENTS (§ 167*)—CONSTRUCTION—ANTICIPATION.
The mere casual reference in the specification of a patent to a given feature will not make it a part of the invention, unless it is relied upon in describing the same.
[Ed. Note.—For other cases, see Patents, Cent. Dig. § 243; Dec. Dig. § 167.*]

8. PATENTS (§ 61*)—ANTICIPATION—EVIDENCE—ACTION OF PATENT OFFICE.
The fact that two applications for patents were pending in the Patent Office and before the same examiner at the same time, and no interference was declared, is evidence that they were not for the same invention, and that one patent does not anticipate the other.
[Ed. Note.—For other cases, see Patents, Cent. Dig. § 77; Dec. Dig. § 61.*]

9. PATENTS (§ 328*)—VALIDITY AND INFRINGEMENT—RESERVOIR FOR STOVES.
The Beckwith patent, No. 787,425, for a reservoir for stoves and ranges, claim 11, is not void for indefiniteness, nor for anticipation, but discloses patentable invention; the combination shown being one of great utility and success. Also, *held* infringed.
[Ed. Note.—For other cases, see Patents, Dec. Dig. § 328.*]

In Equity. Suit by Arthur K. Beckwith against the Malleable Iron Range Company. Decree for complainant.

This is a bill in equity charging infringement of letters patent of the United States numbered 787,425, issued to complainant April 18, 1905, the application for which was made on the 11th day of September, 1903. Prayer for an injunction and accounting.

The answer denies that complainant was the first inventor and discoverer of the improvements described and claimed in complainant's patent; alleges that the said alleged invention in all material points thereof had been anticipated by a large number of patents, references to which are set out. The answer also sets up prior use of the supposed invention in this country for more than two years prior to the complainant's application, and a list of such prior users is set out. For further answer the defendant alleges that said patent discloses no patentable invention; that its several claims are inexact, incomplete, illegal, and void.

The only claim of complainant's patent involved in this litigation is claim No. 11, which reads as follows:

"In a stove or range the combination of the convex and rigid back-plate; the sheet metal reservoir; and means for clamping said reservoir against the convex surface of said plate for the purpose specified."

*For other cases see same topic & § NUMBER in Dec. & Am. Digs. 1907 to date, & Rep'r Indexes

FIG 3A COMPLETE TYPICAL DIGEST OF A LEGAL DECISION

decisions of the Courts, can be applied with great advantage to the publications of the Society, although it would require some modification and adaptation in carrying out the details. The most desirable procedure would apparently be to begin by digesting all papers which are published by the Society from now on, and, in between times, to work backward through the publications until ultimately the Transactions and the Journals would be fully digested.

There are two ways in which the digesting could be done according to the amount of time and expense it was desired to spend upon it. The first way would be to have the syllabus go only so far as to indicate the name or nature of the point being digested, so as merely to tell the searcher in what papers there is any information upon the point. This would make it necessary for the searcher to consult each paper in which the point was treated, but it would save him the trouble of looking at all other papers on the same general subject which might, by any possibility, treat the point, and it would indicate to him the precise page on which the point appeared in those papers in which the point was treated.

The second way in which the points might be digested is to have the syllabi indicate the nature of the point digested, and how the point is treated in the paper. This form of digesting would not only have all of the advantages of the preceding form, but it would often save the engineer from getting out the volume in which the paper appeared and looking at the paper itself, because it would enable him to judge whether or not it is likely to give the precise information he wished.

As an example of the first form of digesting, in which the nature of the point only is indicated, without disclosing how it is treated, the following might be given:

MACHINE ELEMENTS

GEARING

Kind of steel for gears subjected to heavy duty, and details of treatment and machining are given.

Gears for Machine Tool Drives, by John Parker, 1913 Proceedings, p. 785, at p. 787.

As an example of the second form of digesting, in which the nature of the point is stated and also the manner in which the point is treated, the following may be given:

MACHINE ELEMENTS

GEARING

For gears of small proportions, but subjected to very heavy duty, a five per cent nickel-steel has been found excellent. Blanks are preferably drop-forged and given an oil treatment by heating to 1550°F., and quenching in oil; then annealed by reheating to 1350°F. and cooling very slowly before machining. After machining, gears are carbonized by packing in carbonizing material, and heated to 1700°F. in the absence of air for three or four hours. After cooling in the packing, they are then reheated to 1550°F. and quenched in oil, and again reheated to 1380°F. and quenched.

Gears for Machine Tool Drives, by John Parker, 1913 Proceedings, p. 785, at p. 787.

This second form of digesting, while more expensive, might well give the engineer all he wished to know on the point, or, if not, might show him that the information of the paper on the point is along different lines from those on which he was seeking information.

When the digesting is once up to date, the expense of it would be unimportant and by digesting only the principal or generic points of a paper, and not attempting to digest the subordinate or specific points, the expense could be reduced, and the labor of the searcher upon the specific points would be very greatly reduced, because unless a paper contained the generic point, there would be no possibility of its containing the specific point.

It would, of course, be necessary to make the digest or syllabi cards, and also to provide a classification of them so that a searcher could put his hand readily on all the cards relating to the particular point on which he was working. Upon this classification problem, the experience of the United States Patent Office would be of considerable use. The Patent Office has had over 1,100,000 United States patents to classify, so that the Examiners, in making a search to determine whether or not an invention disclosed in an application for a patent is new, can readily find all the United States patents relating to the same subject. Not only this, but the classifi-

cation has been carried out to great sub-division so that when the Examiner is searching for particular details of an invention he may find all the patents which might have such details, separated out into a comparatively small sub-class, and thus reduce his labor to the smallest proportions.

The sub-division of class No. 164 of Cutting and Punching Sheets and Bars, is here reproduced as a typical example of the manner in which the Patent Office classifies all of the patents relating to one particular art (Fig. 4).

**CLASS 164.—CUTTING AND PUNCHING SHEETS AND BARS. (XIV.)**

(See Definitions of Revised Classes.)

*Subclasses.*

1. **Buttonholes—**
3. Knives,
2. Machines,
4. Pliers—
5. Modified scissors,
6. Scissors attachments.
11. **Combined machines—**
13. Die cutting and punching.
14. Pivoted knife-carrier,
15. Reciprocating knife-carrier,
16. Roller-cutter and punch,
12. Work-feeding.
17. **Cutting—**
18. Die—
29. Dies—
31. Adjustable-face,
33. Blank-ejecting,
32. Multiple concentric,
30. Spiral-strip-cutting,
19. Machines—
23. Reciprocating cross-head—
24. Shifting dies,
25. Reciprocating plunger—
26. Lever-operated,
27. Screw-operated,
28. Roller-die,
20. Work-feeding—
21. Reciprocating feeder,
22. Roller-feed,
80. Implements—
81. Pliers,
82. Sweep,
83. Traveling—
84. Roller-cutter,
34. Machines—
35. Band-knife,
78. Cutting-tables—
79. Work-clamping,
36. Fixed-cutter—
37. Spiral-strip,
38. Work-feeding—
39. Roller-feed,
40. Oscillating apertured cutters,
41. Pivoted-cutter—
44. Lever-operated—
46. Compound-leverage,
45. Work-clamping,
43. Transverse,
42. Work-feeding.
47. Reciprocating-cutter—
51. Automatic-clamp,
58. Cutters and bed blocks.
53. Draw-cut—
54. Automatic-clamp,
55. Separately-operated clamp,
56. Fluid-operated,
59. Gages,
57. Lever-operated,
50. Notched work,
52. Separately-operated clamp,
48. Work-feeding—
49. Roller-feed,
60. Rotary cutter—
63. Curved platework,
70. Cutters,
64. Notched work,

**Cutting—**
Machines—
Rotary cutter—
69. Rotary work-mandrel,
65. Slitters and winders,
66. Transverse—
68. Work-feeding—
67. Printing-press attachments.
61. Work-feeding—
62. Reciprocating feeder,
71. Sweep-cutter—
72. Elliptical work,
73. Traveling cutter-carriage—
74. Motor-driven cutter—
75. Reciprocating,
76. Rotary,
77. Roller-knife.
**Expanded metal—**
6.5. Reciprocating,
6.6. Roller.
7. **Fence-barbs—**
8. Cutters and dies—
9. Roller,
10. Processes.
10.5. **Printer's leads.**
85. **Punching—**
119. Implements—
120. Pivoted handles—
121. Pliers—
122. Turret,
123. Traveling-roller,
86. Machines—
118. Dies and die-holders,
87. Feeding and punching—
88. Reciprocating-feed,
89. Roller-feed,
116. Feed mechanisms—
117. Reciprocating,
90. **Gang—**
91. Lever-operated—
92. Foot,
93. Pattern,
94. Hammer,
95. Hydraulic,
96. Lever-operated—
97. Foot,
98. Printers' rules,
111. Punch-selector—
112. Keyboard-controlled—
113. Electrically-operated.
114. Pattern-controlled—
115. Electrically-operated.
99. Roller—
100. Printing-press attachments,
101. Screw-operated,
102. Shaft-driven—
107. Safety devices,
104. Stop devices—
105. Shaft-clutch,
106. Stroke adjustments,
103. Tilting-frame,
110. Strippers and hold-downs,
109. Tie-band tongue,
108. Tube,
125. Processes,
124. Punches.
106. **Scrap-cutting.**

Fig. 4 Typical Patent Office Classification of an Art

While the Patent Office has carried the sub-division of its classification greatly beyond what would be necessary for this Society, still its work would be very useful in devising a classification for a digest for the Society. The Society would only be interested in a relatively small proportion of the entire two hundred and fifty main classes, but the Patent Office arrangement of main classes (together with the definitions of the classes and sub-classes which it publishes of which Fig. 5 is a portion relating to the class shown in Fig. 4) would serve to sub-divide completely, on broad lines, the entire field of work covered by the Society, without overlapping of the classes.

The larger sub-divisions of the main classes would probably be useful in the Society's classification, although the more minute sub-divisions would probably not be needed.

**CLASS 164.—CUTTING AND PUNCHING SHEETS AND BARS.**

Definitions.

*Class.*

This class embraces machines and processes for cutting, including die cutting and punching sheets, plates, or bars of metal, cloth, rubber, leather, paper, etc.

Machines for splitting and skiving of leather are classified in 69, Leather-Working.

Machines specially designed for working on boots and shoes, except die-cutting, are in class 12. Boot and Shoe Making.

*Subclasses.*

1. BUTTONHOLES. Devices for cutting buttonholes, usually in cloth or leather.
2. BUTTONHOLES, MACHINES. Machines for cutting buttonholes.
3. BUTTONHOLES, KNIVES. Buttouhole cutters having a knife form of cutter.
4. BUTTONHOLES, PLIERS. Buttonhole cutters having a plier form.

**Search Classes—**

**164**—Cutting and Punching Sheets and Bars, subclasses 81, Cutting, Implements, Pliers, and 121, Punching, Implements, Pivoted handles, Pliers.

**81**—Tools, subclass 187, Pipe and rod cutters, Pivoted, and subclasses thereunder.

5. BUTTONHOLES, PLIERS, MODIFIED SCISSORS. Buttonhole-cutters in which an ordinary pair of scissors is modified to cut the buttonholes.
6. BUTTONHOLES, PLIERS, SCISSORS ATTACHMENTS. Devices adapted to be secured to ordinary scissors to cut the buttonholes.

6.5. EXPANDED METAL, RECIPROCATING. Machines provided with a reciprocating cutter adapted to slit sheet metal and also provided with means for corrugating or for stretching the sheet.

Note.—Machines for forming expanded metallic lath are classified in this subclass. Machines for forming corrugated metallic lath are classified in class 153, Metal-Bending.

Fig. 5 Definitions of Classes in Fig. 4

It would not be necessary that the Society's digest be printed or published, but if a single, hand-written digest were maintained in the Society's rooms, it could be used by every member of the Society either by personal access to it, or by ordering complete copies of all the digest cards on a particular topic or, at least, a list of the volume and page-numbers of such cards.

The work of digesting the current papers might be considerably reduced by asking those members who were willing to do so, to digest their own papers, although it would probably be desirable to have such digests revised by the person whose duty it was to do the digesting in general.

I believe that a single competent man, working under the supervision of a Committee, could digest the current papers and have the bulk of his time for working backward, digesting the Transactions and Journals, so that in the course of two or three years the entire literature of the Society would be digested. Such a man, to be most successful, would need to be not only able to understand the papers he was digesting, but to be capable of generalization, so that he could condense a section of a paper while preserving its true proportion and import.

In the light of many years' experience with the proposed plan of digesting and classifying records, as it has been applied to the records of the profession of the law, I feel confident that it is thoroughly feasible and practicable to apply it to the records of the profession of mechanical engineering, and long experience with the classification of the

Patent Office leads me to believe it would be of much aid in adapting the system to engineering records. The expense to the Society would not need to be burdensome, as one man could accomplish the work within a reasonable time, and such expense would be small compared with the value of the time saved to the members of the Society. The effect upon the publications of the Society would be to make each paper perpetually "current" instead of their now being usually ephemeral. I recommend, therefore, that the Council be asked to appoint a Committee to consider the question.

## DISCUSSION

Selby Haar expressed the opinion that a digest of the records of the Society would be of less value to engineers than to lawyers. For although it would eliminate most of the labor of acquiring knowledge, it would tend to make one unlikely to remember what he wanted, when he wanted to use this material again. Besides that, the engineer would usually need to get the information much quicker than is necessary in law and patent cases, and would not have time to refer to a digest, which would be too bulky for ready reference.

A. M. Coyle said that he considered the author's idea one of the best suggestions that had been offered to the Society. Much time is wasted in hunting for information, and there is a vast amount of useful material published by the Society, which becomes useless because it is too difficult to find. He suggested that instead of a manuscript digest kept in the Library, there should be a system of cards to be issued to members, at an expense not to exceed $1.00 a year. The slight amount each would pay would very nearly cover the cost of the digest. Once started, the plan would be self-sustaining not only for members, but for a great many other people who would be glad to have the information.

William Kent expressed his appreciation of the paper, and said that the need for such a digest as Mr. Prindle proposed was an increasing one. He suggested that there would be a great deal of cross-indexing for each paper. For example, the paper by D. S. Jacobus, Tests at the Detroit Edison Company's Plant, might be placed under the general head of steam boilers, but should also be cross-referenced under the head of labor questions, because there is in it a statement how to pay wages in the boiler room.

Theodore Stebbins suggested that the Society bear a part of the expense, and a notice be put in The Journal to find out how many would subscribe for these cards, so that the expense might be borne partly by the Society. He thought that besides the set of cards in the Society rooms, there should also be a set on file in the Library and that manufacturers and others who wanted cards should subscribe and finance the scheme in that way. He believed that the records for the current and the future years should be rather fully compiled, and that for previous years, a shorter method be followed to save expense and expedite the work.

Henry Hess contributed a written discussion, in which he said that while the indexing and digesting of the material in the Transactions would be useful, the scope would be limited, just as the digest of only one court would be of limited use. An engineering digest to be broadly useful should include the work of the four National Engineering Societies, and probably also the matter contained in the foremost engineering publications. Moreover, the engineer who would fully post himself on any given subject would have to search not only the literature of the United States, but that of the principal foreign countries as well.

The necessity of something of this nature has long been recognized. Partial digests have been published in the United States, in England, in Germany, in France and in Belgium. Probably the most ambitious undertaking of its kind, the Technische Auskunft, until recently issued every month, was a volume covering the entire world's technical literature in five languages. In Belgium, a monthly Revue Technique is published and indexed under the Dewey system. It is thus clear that there exists a very general demand for this work, but it is equally clear that the demand can best be supplied under the auspices of an association that is not primarily intended for profit making. There is little doubt the work could be made self-supporting, in time, once it is thoroughly started and carried to a point where its value can be recognized. Mr. Hess suggested that the Council refer the matter to the Engineering Foundation, through which the scope would at once be extended to cover the four national societies, associated in the Foundation.

A. M. Coyle said that what Mr. Hess suggested would cover such an enormous area, that it would be difficult to reap any results in the near future. Without delaying in any way the general ideas of Mr. Hess, the American Society of Mechanical Engineers could proceed with its own records as a start.

William Kent said that he would like to see this undertaken by the Society first, and after it had been systematized, the other societies might get out similar cards. He suggested that a conference committee of representatives of the different societies should get up a scheme of indexing that would meet the needs of all the societies.

Selby Haar pointed out the fact that this digesting was not entirely new in the four societies. The American Institute of Electrical Engineers has for some time been presenting with each paper a digest of what it contains. The very complete index of all the Transactions of the Institute, published about a year ago, is so thoroughly cross-referenced that it would serve as a digest. In any intersociety undertaking it would be necessary to reckon with the work already done.

The Author said in closing that he believed it would be better to start the plan within the society, and to leave to the Council the matter of passing it on to the Engineering Foundation. Otherwise the idea would be so expanded, that it would be likely to fall from its own weight. In answering Professor Kent's remarks on cross referencing, he said that his idea was not to put on a single card the entire digest of a paper, but only the point or points which would go under one sub-division of the classification. It would be possible to assemble on one card perhaps three or four points from different papers, but only such as would go under one sub-division. In this way cross-referencing is avoided in legal, and could be avoided in engineering digests.

# BOSTON SYMPOSIUM ON EMPLOYMENT AND EDUCATION

*A Joint Meeting of The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the Boston Society of Civil Engineers was held at Wentworth Institute on the evening of February 26th. A buffet supper was served, after which the new shops and laboratories of the students were inspected. There were over 200 present, and at eight o'clock the audience assembled to listen to a series of addresses, an account of which is given below.*

At a joint meeting in Boston held on the evening of February 26th at Wentworth Institute, four addresses were given on subjects relating to employment and education. These were: The Responsibility of the Manufacturer for Training of Foremen and Skilled Workmen by Mr. Walter C. Fish, manager Lynn Works, General Electric Company; The Employer's Side of the Problems of Irregular Employment by Mr. Henry S. Dennison, treasurer, Dennison Manufacturing Company; Coöperation between Employers and the Schools by Mr. William B. Hunter, director of Fitchburg Industrial Schools; and The Economic Relation between the Supply of Skilled and Intelligent Workmen and Unemployment of the Masses by Prof. Thomas N. Carver, of Harvard University.

The meeting was opened by Principal Arthur L. Williston of Wentworth Institute who said in welcoming the guests that the endeavor of the Institute had not been to reach up into the higher fields of technical education. It was a trade school for the training of the workmen, foremen and master mechanics of industrial plants; and although those who were present were engineers he felt that they and the Institute had a vast field in common.

### ADDRESS BY WALTER C. FISH

Mr. Fish said that he wanted to enlarge his subject at least temporarily so that it would become "The Responsibility of the Community for the Training of Foremen and Skilled Workmen." The manufacturer is helpless if he does not get the coöperation of the community which has such vital interests in the matter and if the manufacturer does not get a decent product from the community his task is correspondingly accentuated. The manufacturer is largely dependent on the educators of the community and the future of this country depends ultimately on education and average intelligence. Mr. Fish also expressed the belief that the early school training of the young man destined to become an artisan should be as far as possible along lines leading to a good general education, and the workshops of the country should take more active interest and more responsibility in supplementing this education. To emphasize this conviction the speaker read an extract from Huxley's essay on Technical Education written in 1877. While some might say that men of that time were likely to be behind the times from the standpoint of today he thought it was fair to say that Mr. Huxley was many, many years ahead of his time. Mr. Huxley said:

> The workshop is the only real school for a handicraft. The education which precedes that of the workshop should be entirely devoted to the strengthening of the body, the elevation of the moral faculties, and the cultivation of the intelligence; and especially to the imbuing the mind with a broad and clear view of the laws of that natural world with the components of which the handicraftsman will have to deal. And the earlier the period of life at which the handicraftsman has to enter into actual practice of his craft, the more important is it that he should devote the precious hours of preliminary education to things of the mind which have no direct and immediate bearing on this branch of industry though they lie at the foundation of all realities.

The speaker, continuing, said that for the last few years he had had more or less control over a large body of men and had constantly been in contact with their work. The practical results of his observation were precisely those suggested by the words of Mr. Huxley. Regardless of whether the young man comes from the grammar school, the high school or a school like Wentworth Institute, his education must be finished in the workshop if he is to be a successful artisan. The manufacturers must round off his education because it is only in the shop that he can obtain certain things which he must have if he is to be successful. Manufacturers must become educators and must more and more attempt the performance of those things which perhaps would have subjected them to ridicule if they had been attempted fifteen or twenty years ago. He would prefer to have a young man come to him who really understood the actual causes of the American Revolution or the Rebellion or the French Revolution than one who perhaps had been taught elementary molding or carpentry. The former was likely to be broader and better and more successful.

This is not an attack on vocational schools; the main thing is to keep the young man at school and certainly in this respect the vocational schools of this country are serving a most useful purpose. They attract and educate many who would leave the public schools at too early an age but who will not leave vocational schools.

Young people leave the public schools at fourteen or fifteen years of age because the public schools of today are not interesting. Many teachers who are thoroughly conscientious and hard-working have not been taught to make grammar and the other so-called dull studies interesting. These things are up to the community and not up to the manufacturer who is not obtaining any too good a product for his workshop. It must be remembered that the manufacturer has to deal with people of whom a large percentage are common people, suited, when they enter his establishment, to do common things. It seems fair to say that not more than one or two at the most out of every ten who enter industrial establishments have any reason to be considered subjects for marked advancement or for educational work on the part of the manufacturer. What shall be done with these one or two out of ten, or it is better still to say five or six out of a hundred? The best answer at the present time appears to be to organize freely and maintain apprenticeship systems. If a young man is to be started in a career he must be guided, by which is meant that he must learn practical things by system. We should make apprenticeships more flexible so that our workshop students will not all be treated in the same way. Better recognition

must be had of the experience and education of each individual to the end that when the boy reaches certain set results, he will pass out of the apprenticeship system into his life work.

The fact was emphasized that the foremen are found, not made. The principal qualification of a foreman is in his own proper individuality which depends in large part on extremely early influences and perhaps more or less upon heredity. The first thing any successful foreman has to learn is the ability to put himself in the other fellow's position. He must not only be a man of good disposition, but one of breadth and understanding.

No one can take ten graduates from any school and teach them to be men of good disposition, possessing the innate characteristics essential for good leadership. If they are not born with these faculties the only thing will be to find others who are.

What is a foreman? In different corners of the shop he must possess all sorts of different qualifications. He may be put into a department where he controls 80 per cent material and 20 per cent labor; he may be placed in a department where he controls 80 per cent labor and 20 per cent material. In this latter department there may be no machinery at all, while in the former department he may have charge of the most complicated machinery. A great deal is said nowadays about efficiency of organization and the importance of the question cannot be overstated. Most manufacturers, unfortunately, find they still must organize with reference to available material, and the qualifications of disposition and ability to control men are often missing in those candidates for foremanship who possess marked abilities in other directions,—technical and mechanical, for instance. There are no definite specifications, and the successful manufacturer will seek in each case for the man who, though helped and trained by his school and apprenticeship life, will have largely made himself suited for the position.

#### ADDRESS BY WILLIAM B. HUNTER

In considering the subject of Coöperation between Employers and the Schools, William B. Hunter said that we hear a great deal of criticism by employers of the product that the schools are turning into their shops, while the boys on their part do not know what trade or business they are fitted for on leaving the grammar or high school.

This is one of the phases of the situation particularly recognized by the coöperative system carried on at Fitchburg, Mass. It was organized because a business man saw that it was a business way of furnishing boys to business houses.

After the boy has spent one year in the high school, he goes to work in a shop as an apprentice. He spends one week in the shop and the next week in the school. He is registered in the shop one whole week and the next week when he goes back to school his place is taken in the shop by another boy. In that way there is no idle machinery and no idle school; machines always going—schools always going.

It is real business for the boy in the shop, unlike most school shops where everything is ideal. The manufacturer takes an intelligent interest in the boy and if the boy is not going right, he sees it. He does not have to take it for granted that the school is teaching this or that; he sees results. The boy is in the shop to work and he is paid by the hour. It is a commercial proposition, not philanthropic.

It is firmly believed that the public schools should take care of this plan of education. The employer is already taxed for public education and the public schools are responsible for the training of our young people. Public school training is the best for the boy. Why should the employer have to duplicate the public school system by putting in a school in his own plant? Instead of erecting another school building the capacity of the present school building is doubled by this system since only one-half of the boys are in school at one time. Then as to the manufacturer who is going to take care of the boys afterward, why should he not be willing to help make better workmen of them? It is a better plan for the manufacturer, and it is better for the boy.

How about loyalty? When a boy starts an apprenticeship course and grows up he certainly will be loyal. If he serves his time with Brown & Sharpe, for instance, later when he goes out he will talk for Brown & Sharpe and the things he saw there. We have found this to be true.

The idea of giving wages to the boys makes it possible for them to continue in the high school; otherwise he might have to drop out before finishing his course. He cannot afford to go to the trade school. The rate paid to the boys the first year is 10 cents an hour—not much but it helps considerably. In a good many cases this is the means of keeping the boy at school. He gets a little more the second year and a little more still the third year.

The average boy after leaving high school is trying his hand at this and at that. He does not know what he is fitted for. With us, if the boy sticks to his course to the finish he has a definite trade with which he can go out and earn his living, not alone in the shop where he spent alternate weeks while at school, but in any other shop.

It has been asked why boys leave the high school. When a boy gets to be about fourteen he wants to earn something and not be obliged to have to ask his father for a quarter now and then. Our coöperative system satisfies the boy's desire to earn money, which makes him willing to remain at school. This is better than having the boy drop his school work and go out to take the first job he can get regardless of what it is, so long as it offers wages.

Then, after graduation he is assured of a job. He is actually a journeyman when he gets through and can go into another city and earn $3.00 a day. He not only has his shop experience, but while in school has been studying shop problems. He has become acquainted with the problems of the workmen and is more serious and earnest than the high school boys who often remain in school simply as an excuse for having a good time. He has learned that a working man is just as good as anybody else, that work is honorable, and that one who gets his hands dirty by work is just as good as one who does not. This is not always the attitude of the young men coming from our high schools. Thus we are teaching the boys democracy and they do not fear that they will be looked down upon for going to work in the shops after graduation.

A good many of the manufacturers visit the schools and help solve some of its problems. We teach in Fitchburg the metal trades and allied trades: machine-work, pattern-making, saw-making, drafting, iron-molding, tin-fitting, piping, printing, textile and office work, and it is planned later to take up the building trades and even farming. The manufacturer meets with the director each month and discusses the

various problems as they come up. He tells what we ought to do to help him and we frequently go around to the shop and see for ourselves.

A number of leading firms in Fitchburg are coöperating with this school. Most of the larger machine shops and textile plants have been willing to take some of our boys every year which shows the plan to be a success. This idea is not confined to Fitchburg alone. There are similar undertakings at Providence, R. I., Springfield, Vt., Chicago, Ill., York, Pa., Lansing, Mich. and other places. It does not cost anything to start the system; no shops or machinery have to be put in the school, but instead, the live commercial going shops of the city may be used. Our cities are all poor. By our coöperative method, they are getting dividends on education. Our boys have made over $100,000.00 which has gone into the pockets of the citizens. It is giving the workman an education so that he will make a better workman and be fitted in many cases for a future foreman.

### ADDRESS BY PROF. THOMAS N. CARVER

Professor Carver spoke on The Economic Relation Between the Supply of Skilled and Intelligent Workmen and Unemployment of the Masses. He said that one of the elementary commonplaces of economics is the observation that all men do in industry is to move things about from one place to another. Back of this process of moving things there is at least a purpose, which, it may be fairly stated, is to get things together in the right proportion.

Whether one is a chemist mixing a compound in a laboratory or an engineer digging a swamp, irrigating a dry plain, or erecting a building, he is simply trying to get things together in the right proportion. All this requires human labor, and today the distribution of human talent has more to do with the bad distribution of wealth than any other single factor. In comparison with this, other things are trivial—getting human talents of various kinds combined in the right proportion.

Now suppose that material things are in the wrong proportion for common use, as, for example, the water in the swamp just referred to, there being too much water in proportion to the soil. While it may be perfectly good water, it is not worth much there. Only a certain supply of water is necessary to make plants grow. It is the bad proportion between water and soil which makes water so cheap.

Again, if one is trying to make gunpowder which is composed of a mixture of saltpeter, sulphur and charcoal, he may have more charcoal than he can use but not a sufficient supply of one of the necessary materials. Charcoal must therefore be cheap. This illustrates just the problem that is met with in unemployment. One can try a laboratory experiment and put the proposition to the acid test. Let one disguise himself as an unskilled workman and go out looking for an employer. Then go out as an employer looking for unskilled workmen and see under which condition there is the greater difficulty. The situation is exactly the same as in the case of gunpowder in our illustration—no matter how great the demand for gunpowder one cannot use the charcoal. The charcoal is out of employment because one cannot find enough saltpeter to mix with it.

It would seem as though since there is a demand for commodities, there should also be a demand for labor. The demand for commodities in itself will not and does not give employment unless there is something else. No matter how great the demand for commodities nor how great the supply of manual labor, unless there is the employing talent in between, you cannot use that human labor. This is a bad distribution of human talent; too much of one kind and not enough of another kind.

There is an idea abroad that there must be available means of employment for everybody. Since labor produces all the wealth, there must be a demand for labor. But here is where the first principle of economics should be applied. There must be some other things besides unskilled labor, if wealth is desired. The difficulty is that there is not a sufficient supply of skilled labor to do the skilled part while the others do the unskilled part; splendid charcoal but not enough saltpeter.

Now if it were possible by some miracle to transform the charcoal into saltpeter it would, of course, be an immense help to the situation. By transforming a little of the charcoal into saltpeter one could then use the balance of charcoal. Similarly, if we could only transform one kind of labor into another, our problem would be solved. The chief value of education of any kind is that it tends to redistribute human talent and train men for positions where men are scarce. That is the miracle which will transform the charcoal into saltpeter. Put these things together in the right proportion and if we can do this thoroughly there will no longer be unemployment.

This trade training is excellent as far as it goes, but there is danger that it may stop too soon. Our greatest need is not for skilled laborers. Of course we need them, but employers are what we want. What we ought to do is to try to bring about conditions where there will be two employers where there now is one. Make more employment for labor and wages will rise.

There are different kinds of skilled labor which have to be combined: the skilled labor of the manager and of the investor, the man who knows how to start an enterprise. The man most needed is the man who can see opportunity for a new enterprise, and not only see it but make it go and produce a favorable balance sheet,—such a man is even more important than he who can make two blades of grass grow where only one grew before.

There is no such thing as eliminating poverty or unemployment until we make employment enough to absorb all the men who are now looking for jobs, and a little more,—until we can make two jobs where there is but one man, so that the employer has a hard time finding labor. Employment must be more plentiful than labor. At the present time perhaps ten men will apply for one job. Poverty will be eliminated when conditions are reversed and ten employers will be seeking the services of the same man.

It just depends upon how much we really want to get rid of unemployment and of poverty. If we want to enough we can do it. It will mean a harder time securing workers if we have to compete for every man. Chasing after him will mean a little more inconvenience, but wages will be better for the workmen.

In addition to increasing the number of employers, we can do something toward thinning out the number of the unskilled. Education is itself thinning out these numbers. Every time a man is trained out of the unskilled class there is one man less there, unless more come in from the out-

side, and a little restriction at that point would be beneficial. Some restriction of the inflow of labor from the outside would go a long way toward thinning out the ranks of the unskilled. After a while when the employer advertised for a workman, there would not be anybody after the job.

This point is so absolutely clear and simple that I do not take anybody seriously who professes to have any interest in the labor problem and yet does not want to see immigration restricted. It sounds well to say that we must keep our doors open to the poor and oppressed of the world, but I am inclined to think that the appeal to the pocketbook is rather stronger than the appeal to sympathy.

About equality: If one man can do twice as much as another, he is worth twice as much. As between bricklayers and bank presidents there can be equality by making it as hard to find a bricklayer as it is to find a bank president and their wages will be the same. All this comes down to the question of supply and demand.

To go back to the saltpeter argument. In the condition where there is more charcoal than will combine with the smaller supply of saltpeter existing, one will be cheap and the other will be dear. There is nothing unjust about it. The price of one depends upon the existing supply of the other when they both have to be combined to make the gunpowder. The only way to equalize the value is to produce more of the saltpeter or shorten the supply of charcoal. It is a very plain question of supply and demand.

On the dry plain, water is necessary for the production of plant life. Water should be worth a good deal there, but it is not worth so much in the swamp where there is too much of it. If we could bring the water from the swamp to the dry plain, the ideal condition would be reached. In the same way labor is more productive and profitable where there is opportunity to use it. When one kind of labor is as much needed as another there will be equality.

### ADDRESS BY HENRY S. DENNISON

In speaking of Irregular Employment, Mr. Dennison said in part, there are three classes into which we must divide irregular employment in order to see it at all clearly. One has to do with the long cyclic changes of business prosperity and depression; another with business changes due to the season of the year; and the third, with the rate of labor turnover in mills and factories,—that is, the frequency of hiring and firing.

Let us consider some of the waste which is caused by irregular employment. Mr. M. W. Alexander of the General Electric Company has worked out figures showing estimates ranging from $39 to $150 as the cost of each new employee, and when one considers the amount of spoiled work, the amount lost on overhead from short product, the cost of training the new man, the cost of hiring, etc., $30 is a pretty conservative estimate of the loss caused by hiring a new employee.

Another loss which comes from irregular employment is due to the slackening of speed during the dull seasons and the difficulty of getting back speed when times become better. Even where the employees are on piece rate, they will take all the time they like in such off seasons because there is only a limited amount of work for them and after such periods, it takes a long time for many people to get back into the stride again. Then there is the opposite extreme of overtime at the opposite stage of the season. The factory that can run with a given crew, that gets more and more into its stride and more and more productive, is a lucky shop.

In the building trades where the men are able to find employment only at certain times during the year, they must have high rates of wages for the time they do work to make up for the periods when they are without work. In many cases a long period of unemployment causes permanent injury to the efficiency of the workman.

Again, in connection with shifting employment is the lack of loyalty. Loyalty cannot be developed in the employee who is jumping about from shop to shop.

So much for the cost of irregular employment. What can we say as to the causes and possible chances for improvement? In connection with the cycles of business depression and prosperity, one cause of our difficulty is our complete lack of information about real business conditions at any given date. Many things ought to be known about the stock on hand, about the actual volume of trade, etc. If we could see more clearly where we were at any stage of the game, we could provide more wisely and provision against future difficulties would do more than anything else to prevent those difficulties from coming. If we have gone along in a period of prosperity and signs indicate that sooner or later we shall have a period of depression and we hedge a little for it, the general results will be more wholesome; for while we shall not have so much prosperity for the time being in consequence, neither shall we have so much depression at a later period.

For the seasonal unemployment the causes all finally rest upon weather conditions which affect building trades, the handling of perishable food-stuffs, and indirectly the styles of clothing. One influence that may work toward the betterment of seasonal irregularities is the closer relation between the manufacturing and the selling ends. This we have found, ourselves, to be extremely valuable. Letting both of these departments run without intimate connection caused very considerable difficulties, whereas, when we brought them together and made each serve the other we found large improvements in getting orders out earlier for delivery, anticipation of orders wherever possible, etc.

The weather conditions which affect the building trades to such a large extent presents a technical problem extraordinarily difficult. During some months the contractors do not keep more than 5 per cent of their men and the other 95 per cent are discharged. And even though some of these men—bricklayers, carpenters, etc.—do receive $5.00 per day while they work, this often means only $600 or $700 a year as their total income. Every effort possible must be made to regularize these trades.

The effect of weather conditions in other trades, such as in the candy trade, for instance, has been considerably helped by the refrigerating process; and other technical means can be found to avoid these other difficulties if we are only persistent enough about it.

The irregularity of employment which results from a rapid labor turn-over is a very serious loss to employers, which is very little appreciated. Mr. Alexander found in a group of factories which employed 38,700 employees at the beginning of the year 1912, and 46,800 at the end of the year, that they had hired 44,365 people, indicating that over 36,000 people had dropped out of employment during the

year. Allowing for all the inevitable causes of withdrawal, such as death, sickness, etc., he finds in these industries over 22,000 people engaged above the seemingly necessary requirements. This means to these industries a loss of at least $750,000 a year. In one employing 11,000 people at the beginning of the year, he found that 17,000 had been hired through the year with practically no permanent increase in the crew. And in all the labor turn-over exceeds 50 per cent.

The causes are many and vary somewhat with each factory. They can probably be studied best and most readily corrected through the establishment of a very efficient employment department.

In all these three classes of irregular employment the employer has the largest opportunity to improve conditions and has also the largest amount at stake. Here is a preventable waste, costly to employer and employee alike, in which any improvement will be of financial benefit, will be a help to our country in competition with other nations, and will be a social service.

#### WENTWORTH INSTITUTE

Wentworth Institute, which acted as host of the evening, was opened three and a half years ago, founded by Aricoh Wentworth, a marble manufacturer of Boston, who bequeathed in his will $3,500,000 for the purpose.

The institute aims to train workmen of the most competent and expert type, foremen and master mechanics. The shops and laboratories, which were inspected at the time of the meeting, are admirably adapted to the special purposes of instruction for which they are planned and their equipment is most complete.

During the short time that the school has been in existence it has grown rapidly and now has nearly 1300 pupils enrolled in its day and evening classes and additional buildings are soon to be erected. It has already given instruction to 3820 students and granted certificates of graduation to over 875 persons who have completed its courses.

The instruction which is offered is of two grades: first, short one-year courses for young men who wish with experience to become high grade mechanics; and second, longer courses for those who have already had practical experience and who wish to become foremen, master mechanics, or superintendents. A wide variety of courses is offered and the aim is to reproduce actual commercial conditions in the shops and laboratories of the school and to work out new courses of applied science as required for the various trades or branches of industry to supplement and go parallel with the practical instruction. This enables the student to understand the technical features of his trade and the fundamental principles of science upon which the trade is based.

# SUBMARINES

BY G. E. FURBUSH, SYRACUSE, N. Y.

Student-Member

At a meeting of the Syracuse University Student Branch of the Society held February 12, 1915, an interesting illustrated address was presented on the subject of the modern submarine boat, by Grant E. Furbush, secretary of the Syracuse Student Branch, which proved of interest in view of the active part that has been taken by this form of water craft in the present European war. The author traced the history of submarine boats from the crude efforts of Symons in 1747 up to the present time, and gave detailed information concerning modern practices in this country and abroad. His conclusions, drawn from a careful study of present developments, are of interest, and are here given.

From the mechanical point of view, the submarine is still in a transitory state. Until it is made more powerful, given a higher speed, and has a much wider radius of action, its success must be limited, even in attacking vessels in harbors, particularly in the presence of the latest system of submarine defense. All of these qualities call for increased dimensions, which increase their cost and reduce their handiness, especially in harbors and comparatively shallow waters.

Every increase in the size of a submarine also adds to its visibility when running awash, and increases the time and distance required for disappearing if the vessel has to dive. The difficulty in diving at a steep angle has reference to the electric storage batteries and to other vessels containing liquids where alterations in the level introduce disturbing influences. The acuteness of the angle of dive, also intensifies the difficulty of subsequently bringing the vessel to an even keel, and increases the danger of the vessel striking the bottom, a danger which has involved the loss of at least two submarine boats of comparatively small size. Greater depth of water is required for such operations, so that only small vessels can be used in attacking ships in harbors.

Because of the many variants and the demand for such careful research, slow progress is being made, but the evolution of design can not be hastened. What is demanded on the part of naval authorities is to move with as much rapidity toward improvement as is consistent with the insurance of reliability in each vessel built, and at the same time to maintain as much secrecy as possible.

Thus, from all that has been done the past few months, it is found that the menace of the submarine is really serious. The trouble with it is that it is altogether too small and too slow for deep sea cruising and for the fighting of deep sea battles. When it has reached a displacement of 3,000 tons and can steam at destroyer speed, the type will realize its unquestionable latent destructive power. Then the battleship will have to look to its laurels.

# FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

Every day shows more and more that in engineering nothing should be taken for granted. When first internal combustion engines were designed, the speed of water flowing through the engine jacket was determined off-hand, simply by making the pump as small as could be without alterations, just because the engine ran after a fashion with an efficiency satisfactory for practical purposes. In a paper before the Cleveland Engineering Society, J. B. Merriam shows that the temperature of the water in the jacket has been limited because of secondary phenomena (the formation of bubbles of steam on the walls of the jacket and consequent spheroidal action due to the limited speed of the water). Experiments and then design of machinery of commercial sizes have shown that if the speed of water through the jacket be made approximately ten times as high as usual, the temperature of the water in the jacket can be raised from around 150 deg. to about 250 deg. fahr. without injurious effects, and thus an interesting way of recovery of heat losses can be devised.

In the Foreign Review Section, the first article is an abstract of an investigation on the action of an air jet on the surrounding air, where the methods of tests are described and velocity, volume and energy curves given. The data obtained in this investigation are of considerable interest for air jet machinery and, to a certain extent, to fan manufacturers.

In the next article is discussed a method of electrically determining the efficiency of large water turbines, describing both the mechanical and the electrical ends of the apparatus and methods used. Both cases of separate and self-excitation are covered and the limit of errors discussed.

Henry Lossier investigates the subject of lateral flexure of hollow pieces and develops new rules for the calculation of stresses in structures consisting of two parallel members united at regular intervals by cross-pieces. He gives a formula which he compares with the old Euler formula and the more modern Timoshenko formula, and shows that his formula agrees fairly closely with the latter.

Prof. J. Fischer Hinnen discusses the question of axial loads on radially loaded ball bearings and shows how a play in the bearing brings about very serious additional pressures on the bearing. He also calls attention to the pitting to which shafts on which ball bearings are running are often subject, and ascribes it to electrolytic action indirectly due to the fact that the belt pulley, or equivalent member, is sitting too tightly on the shaft.

Data on evaporation tests with pressed peat and peat coke as values are reported in an abstract from a German publication. Also from a German publication is taken an abstract of tests on the mechanical properties of teak wood.

From the Memoirs of the College of Engineering of the Kyushu Imperial University at Tukuoka, written in German, is taken the abstract of an investigation on the bending elasticity of cast iron, of considerable interest because of the lack of reliable information available on the behavior of cast iron under either tension or bending.

A paper by H. C. Richardson, on hulls for aeroplanes brings us into a comparatively new field of research. The author indicates the essential points of difference between aeroplane hulls and what he calls "boats working in ordinary displacement conditions." The subject of the action of suction on a boat travelling through, and perhaps out of water at high speed has been investigated thoroughly and important conclusions as to the water resistances arrived at. It appears further that a form of hull has been devised for the navy, having decided advantages over those already in use, so far as resistance on the surface and in the air is concerned.

The subject of motor cylinder lubrication is discussed by G. S. Bryan, U. S. N., in a paper before the American Society of Naval Engineers. Among other things, the writer shows that what is generally known as carbon deposits in the cylinders, does not as a rule essentially consist of carbon. He shows further that the flash point of lubricating oil, while important, does not affect the possibility of the oil adhering to the cylinder walls to the extent often assumed.

Two papers of undoubted value are printed in the journal of the American Society of Refrigerating Engineers, by H. C. Dickinson and N. S. Osborne, of the Bureau of Standards at Washington, D. C. One concerning an aneroid calorimeter, in which copper acts as a calorimetric medium for the transmission and distribution of heat, such calorimeter having several important advantages over the usual stirred water apparatus. The other paper contains data of painstaking investigation of the specific heat of ice, especially near its melting point as well as corrected values for the heat of fusion.

J. Irving Lyle, in a paper on air conditioning (Engineers Club of Philadelphia) illustrates the wide possibilities of applying the control of temperature in industrial plants (bakeries, candy factories, printing establishments, etc.) and the great hygienic benefits which can be secured by it.

A series of tests made to determine the type of coating best suited for the protection of metal imbedded in concrete against the action of electrolysis, as well as the bond between concrete and painted metal are described by Henry A. Gardner, (Franklin Institute) and among other things, the author describes a method of increasing the bonding between the metal and cement by applying to the painted surface while still tacky, sharp particles of fine clean white sand, thus forming a rough surface resembling coarse sand paper.

The interesting subject of the production of oils from peat is treated by Dr. F. Mollwo Perkin (Institution of Petroleum Technologists). While the author is by no means sanguine as to the commercial possibilities of such a production, he does not consider the difficulties in its way insurmountable.

The calculation of centrifugal stresses in turbine rotors forms the subject of a paper by William Kerr, before the Scientific Society of the Royal Technical College, Glasgow. Only the parts concerning solid shaft rotors and hollow shaft rotors are abstracted in the present issue. The second

part of the paper will be abstracted in an early issue of The Journal.

The timely subject of the high speed, high efficiency eight cylinder V-Type engine is discussed by D. McCall White, who is responsible for one of the earlier American automobile engines of this type, before the Society of Automobile Engineers. As compared with the former four cylinder engine, the eight is about equal in length, is only wider by 2 in., weighs from 50 to 60 lb. less, uses a short 4-throw crankshaft and is expected to outlast considerably even an equally well designed and made six.

Interesting tests on high speed steel drills are reported in a paper on High Speed Steels, by Fred C. A. H. Lantsberry (West of Scotland Iron and Steel Institute). Among other things, he found that the efficiency of steels as drills increased to maximum when the content of tungsten rose to 14 per cent and then fell off with further increases in tungsten. Vanadium in small quantities proved to be useful, but steel containing one per cent of vanadium above the quantity eliminated in manufacture, was found to be of absolutely no use for drills.

# FOREIGN REVIEW

## Air Machinery

### Action of an Air Jet on the Surrounding Air

The article is an abstract of a university thesis based on experiments carried out in the mechanical laboratory of the Technical High School in Karlsruhe, and proposes to investigate the loss of concurrent motion of surrounding air produced by a jet of air flowing through a nozzle.

When a jet of air discharges from the nozzle of a blower into the free atmosphere, a part of its energy of flow is transferred to the surrounding air, the friction between the various layers of air acting as a medium of transmission. What the author investigates is

*a* The shape which the stream assumes after its discharge from the nozzle.

*b* The exchange of energy between the active nozzle stream (core stream) and the passive stream of the surrounding air carried away by the active stream (jacket stream).

The article describes in detail the experimental installation and method of tests and then proceeds to the discussion of the results obtained. The velocity curves, which he denotes as *c-r* (compare Fig. A), where $c$ is the velocity of air and $r$ is the radial distance of the point of measurement from the axis of the air jet. Such *c-r* curves as have been obtained indicate a rapid decrease of the velocity of jet with the increase of the distance from the nozzle. Immediately at the exit the velocity curve (1 in Fig. A) is practically a horizontal line, that is, in all points of this cross-section the velocity of air is equal. In the next cross-section investigated ($x = 20$ cm.) this uniformity of distribution obtains only within a certain area, the diameter of which is equal approximately to one-half the diameter of the nozzle, and the air lines on the outer edge of the jet and in its neighborhood have already lost a considerable amount of their velocity. The next curve has no longer any straight section at all.

From the *c-r* curves, the author develops the volume curves by means of the following process. He assumes that the cross-section of the nozzle is a circle and that at each cross-section at points of equal distance, $r$, from the axis of the jet, the velocity of air $c$ is equal; then for an infinitely thin ring of thickness $dr$ the volume of air flowing through it per second is expressed by $dV = 2\pi rcdr$, and, therefore, the volume of air flowing per second within a circle of radius $r$ is $V = 2\pi \int_{r=o}^{r=r} crdr$. This integral can be solved graphically by means of the *c-r* curves found experimentally; it is, however, not the velocity curve itself but rather the curve derived from it, *cr-r*, that has to be integrated.

The product $cr$ can likewise be found graphically, but it is more convenient to determine it by calculation, (the author gives a special table to facilitate this), and then plot it graphically over $r$ as abscissae. The curves of integration obtained from the *cr-r* curves (Fig. C) then give for each cross-section a definite volume corresponding to each value of $r$, this volume indicating how much air flows per unit of time through a circle corresponding to the given $r$, while the terminal point of the curve, by its ordinates, indicates what total volume of air per second passes through the cross-section of the jet. The graphs in Fig. B show that with the increase of the distance from the nozzle, the terminal point of the crowd of curves which start originally like an *S*, gradually diverges in a diagonal direction, always farther and farther away from the zero point, showing thereby that as the distance from the nozzle increases the radius of the entire jet of air, as well as its volume, increase also. If the radii were plotted as ordinates over the $x$'s of the axis of the nozzle (there corresponds to each curve and value, a definite distance of cross-section) the *r-x* would indicate the extreme meridian line of the jet.

It would be of still greater interest to plot on the same system of coördinates those values of $r$ which correspond in the various sections of the jet to equal V. The plotting of such values on the *r-x* system gives a nearly exactly straight line. It appears, therefore, that the active core stream expands conically. By this method of handling the volume curves, the author creates a clear conception of the location of meridian lines limiting the passive jacket stream. From this, he passes to the determination of the amounts of energy contained in the various parts of the jet.

The transmission of energy between various layers of air at different velocities may be also determined graphically from the velocity curves found above. The kinetic energy carried by air volume $dV$, passing per second through an annular area of thickness $dr$ is

$$dE = \frac{c^2}{2}\frac{\gamma}{g}\,dV = \frac{\gamma}{g}\,2\pi rc\,\frac{c^2}{2}\,dr.$$

The latter because $dV = 2\pi rcdr$. Hence the energy of the volume of air which flows through a circular cross-section of the radius $r_k$ is

$$E = \pi\,\frac{\gamma}{g}\int_{r=o}^{r=r_k} c^3rdr.$$

By $r_k$ in each cross-section under investigation is understood that value of $r$ which is found by the process described in the preceding paragraph for the gradual increase in the friction of the jet of radius of the active core stream. Hence, the integral gives the amount of energy contained in the respective sections of the core stream. If it should be integrated now up to the value of $r$, corresponding to the velocity $c = 0$ or

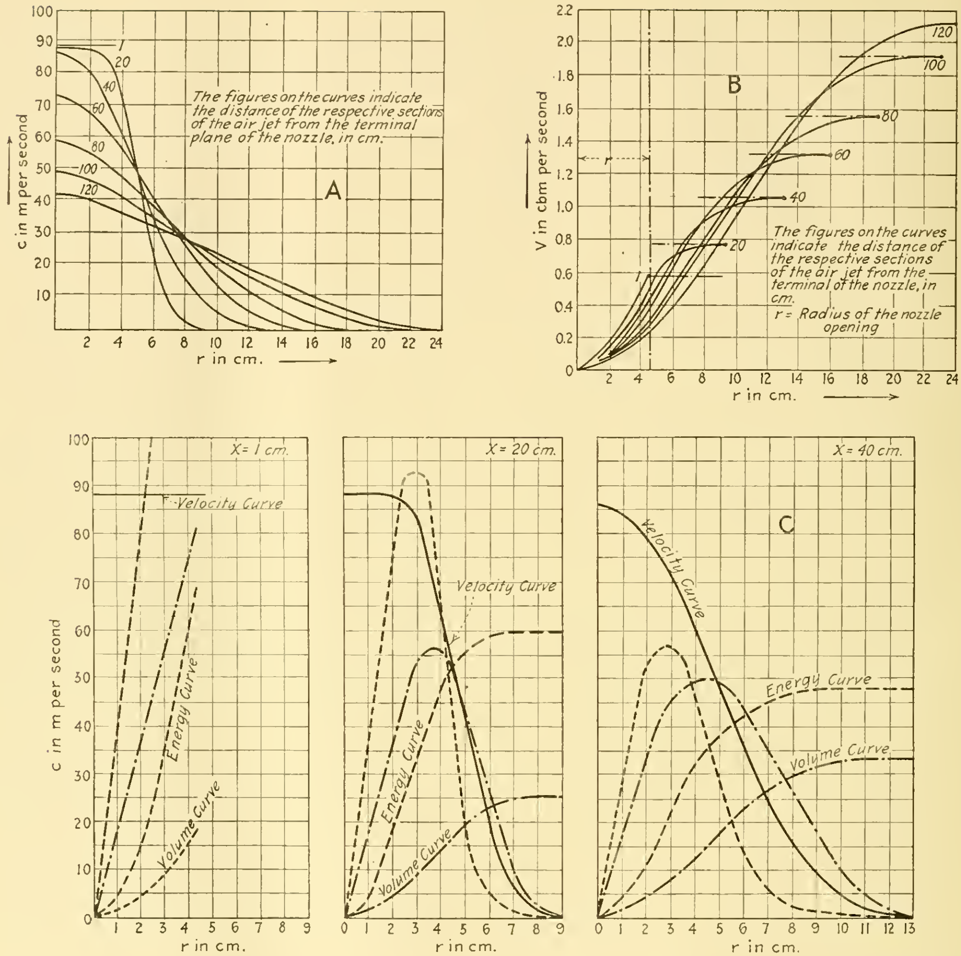
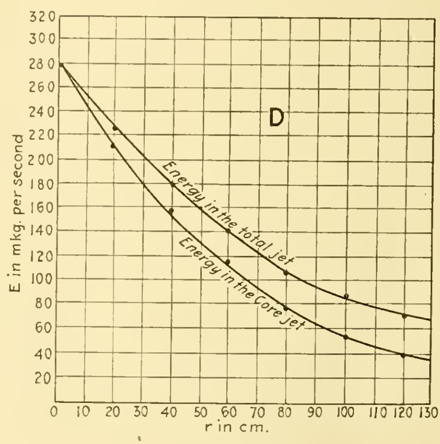



Fig. 1 Action of Air Jet on the Surrounding Air

A. Velocity curves ($c-r$); B. Curves of volume as function of distance from nozzle ($V-r$); C. Volume curves and curves of integration of the $cr-r$ curves; D. Energy curves for total jet and core jet




up to the limit of the jet, we obtain the total energy of the moving stream of air. The difference between the two integral values, that is, the difference between the energy of the total jet and that of the core stream, represents the energy in the jacket stream.

For purposes of graphical solution, the numerical values of $c^3r$ are calculated and plotted as ordinates over the values of $r$ as abscissae; then an integral curve is constructed for the $c^3r$-$r$ curves thus obtained. We obtain here again $S$-shaped curved lines which start, like the volume curves, from the region of coördinates. Contrary to those latter, however, the terminal point of the distance from the nozzle approaches nearer and nearer to the $r$ axis, while in the course of flow the volume increases as the energy contained in it constantly

decreases, more and more. Now if these values of energy be plotted over $x$ as abscissae, each on the $E$-$r$ curves belonging to the limiting value of $r_k$ and of $r$, which corresponds to the velocity $c = 0$, we obtain two series of points of which one represents the variation of energy in the active core stream and the other in the total stream (Fig. D). At the opening of the nozzle, in both of them, the decrease of energy is maximum, but with the increase of distance from the nozzle, the amount representing the decrease of energy, either in the core or the total stream, becomes smaller and smaller as indicated by the decreasing inclination of the curves. Finally, the value of energy must sink to zero, which happens for both curves at the same value of $x$. Experimentally the investigation could not be carried to this point.

The energy curves of Fig. D, obtained from the above experiments, indicate in particular that the energy in both cases falls off very rapidly and that the larger part of the energy contained in the jet is not carried away by the latter but is wasted on the way through friction and eddy formation. Even at a distance from the nozzle as little as $x = 60$ cm. the amount of energy contained in the inner stream was only one-half of the energy which the stream had as it left the nozzle. This loss of kinetic energy ought to be compensated for by an increase in some other form of energy; in this case, the increase in temperature. This could not be established experimentally, however, both because, as the author shows by calculation, such an increase in temperature would be very low and especially because this measurement in the rapidly flowing air is extremely difficult.

From this, the author proceeds to the determination of the coefficient of friction. The article contains several tables of data obtained from these experiments; among others, values of velocity of air, mechanical value of constants in the equation of curves $cr$-$r$ and $c^3r$-$r$. Computation of the friction coefficient $R$ and the table for converting the values of $R$ given in engineering units to $\eta$ (expressed in c.g.s. units). (*Über die Einwirkung eines Luftstrahles auf die umgebende Luft,* Dr.-Ing. Theodor Trüpel, *Zeits. für das gesamte Turbinenwesen,* vol. 12, nos. 5 and 6, pp. 53 and 66, February 20 and 28, 1915, 10 pp., 13 figs. *et*).

### Hydraulics

Electrical Methods of Testing Hydraulic Turbines.

The guarantees given nowadays by manufacturers of hydraulic turbines are very strict and it is therefore of importance to have a convenient method for testing them, especially when in very large sizes. The author recommends to test electrically machinery driving electric generators, and describes a method for determining by means of very simple apparatus the losses and efficiency of alternating current generators and driving machinery coupled with it. He discusses in particular a case where a single phase synchronous generator was directly connected with a Pelton turbine provided with ellipsoidal blades and needle nozzle. The losses of the machinery, either electrical or hydraulic, were not previously known. The exciting current was in one instance taken from a separate source and in another, from an exciter generator driven by a belt from the main turbine.

With the water turbine (quantity regulation), the useful output varies, as experiments have shown, in the lower part of the curve, as a straight line function of the water volume and in its upper part, either as a straight line or as a line slightly curved (according to circumstances), the assumption being that the speed is constant and that at the turbine inlet there is a constant water pressure. The point of intersection with the axis of abscissae can be easily determined by measuring the water consumption of the turbine with the generator uncoupled. The lower section of the line of output has at first been assumed arbitrarily, starting from the no-load point of intersection (curve $a$, Fig. 2A). The turbine can now be temporarily considered as a calibrated motor and the no-load and short-circuit load of the generator can be determined with *first approximation* by means of this $N_m$ line. These losses are shown in Fig. B as "1 results" curve. Next, a series of tests was carried out by varying the loads, and the useful output of the turbine $N_m$ was determined on the basis of the output measured and the generator losses previously found (curve $b$, Fig. A). The exciter losses were not considered in this connection because they were taken care of by a separate machine. The fact that $N_m$ line found with these load tests did not coincide with the line previously assumed shows that the line $a$ was evidently taken too low. The friction, iron and copper losses, as found in the first four series of tests, were now corrected on the basis of the curve $b$, and the useful output of the turbine, as obtained from the load tests, changed in accordance with the corrected generator losses, this giving curve $c$ in Fig. A. It must be pointed out in this connection that the tests themselves did not have to be repeated: only the calculation is repeated, and even this applies only to two or three small loads or losses. Curve $c$ gives another basis for correcting the iron and copper losses. It is, however, clear that within the region used for the determination of the losses, the curves $b$ and $c$ would practically coincide provided the assumed curve $a$ is not too far from actuality. This assumption may be made, for example, on the basis of the guaranteed efficiency of the manufacturers. This method is apparently nothing but the "regula falsi" applied to engineering measuring.

In connection with the carrying out of these tests, the following may be of interest:

*First.* The measurement of the volume of water was made by means of overflow with lateral contraction. Previous to the test, it was calibrated by means of a reservoir and points on the curve were taken for quite small amounts of water. It was found that the Frese coefficient of overflow agreed best with the experimental data.

*Second.* The head of fall was measured by a precision manometer in front of the turbine inlet. The fall was maintained constant by means of a slight throttling by a gate valve, located in the pipe somewhat to the rear.

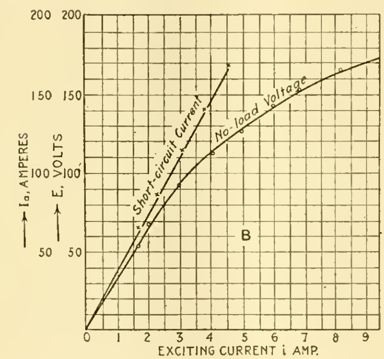
*Third.* A constant speed of rotation was maintained by adjusting the needle of the nozzle with a hand wheel until the tachometer indicated the desired speed.

*Fourth.* The alternating current produced was converted into heat in a non-inductive water-cooled wire resistance. The output as indicated by the watt meter was very nearly equal to the product of current voltage.

*Fifth.* With direct current, cold, the resistance of the armature winding was 0.026 ohms, while the direct measurement of the copper losses showed an effective resistance of 0.07 ohms, the difference being due to additional eddy cur-

rent losses and to the rise of temperature in the armature copper. These additional losses are taken care of by a corresponding increase in the value of the direct current resistance. Had they been neglected, it would have led to an error of considerable magnitude. With a load of 126 amperes, the difference would have been 0.7 kw., equivalent to an estimation of the efficiency of the turbine about 3 per cent too low. It is worth while to note that it appeared that the effective resistance of the armature increased with the smaller current, due to comparatively large iron losses at short-circuit in this particular machine.

*Sixth.* The electromotive force at load was calculated in the following manner. The total excitation field at load, which has to be applied as composed of the resultant field and short circuit field, in the present case expressed in terms of excitation current, is $i^2 = i_k^2 + i_r^2$. The short circuit characteristic (Fig. B) gives the short circuit exciting current $i_k$, corresponding to each armature current $J$. From the short circuit exciting current $i_k$ and the exciting current $i$, measured on load, can be calculated the excitation component corresponding to the resultant field $i_r = i^2 - i^2$ and the emf on load which belongs thereto can now be taken direct from the no load characteristic of Fig. B. If instead of this emf on load be used the terminal potential, this will lead to establishing the generator losses as being too slow and hence the efficiency of the turbine will appear too low also. In this case, however, the error is usually small and amounts at maximum load to only about 0.6 per cent against the turbine efficiency.



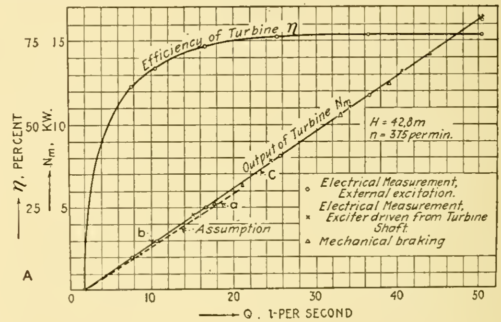




FIG. 2

A. Output and efficiency of free jet turbine at constant head; B. No-load and short-circuit characteristics of single-phase generator (n = 375 r. p. m.).

In tests of large turbines it is not always possible to regulate, in a simple manner, the water resistances so as to obtain different loads at constant terminal potential. On the other hand, it is always very simple to get any load, however small, by exciting for small voltages with constant water resistance. If both methods of varying the load are practicable, a means of control of measurement of the generator losses is thereby additionally provided.

The efficiency of the turbine in the tests carried out by the author has been found comparatively small and he remarks in this connection that from full load to half load, it is 80 per cent, if the turbine is driven at its best speed of 500 r.p.m. with the designed head of 42.8 m. (140.3 ft.). The low efficiency may also have been due to the fact that the turbine and generator were not built for the same normal output (turbine for 16 kw. and generator for 20 kva.).

If the main turbine is to drive in addition to the generator the exciter also, the electrical measurements may be carried out in the same manner as above described, but the output of the exciter has to be determined by a separate series of tests. Such a test might have been carried out with the same apparatus as indicated above, a d.c. generator being driven from the turbine shaft by a belt. In the first place, one has to determine the losses of the exciter at no-load. After that, the exciter losses are determined separately and subtracted from the respective outputs of the first series of tests so as to determine the iron losses. This, however, requires the cutting out of the generator excitation in the second series of tests. To do this, the generator is uncoupled and the rotor set out of motion thereby. Then the field windings serve as a load resistance to the exciting current. In many cases where this cannot be done, it is necessary to have the exciter operate on a separate load resistance. Another method might be to repeat the first series of tests with separate excitation. This would give at once the iron losses and the exciter losses would appear as the difference between these outputs and those of the first series of tests.

A method of measuring water by overflow used in the present tests proved to be extremely convenient and exact. In water power plants it is not always applicable, especially where the volumes of water are very large, in which case they have to be measured by vanes. In this case, the loss measurement of the turbine output may be determined as a function of some geometric magnitude, for example, servometer stroke or indicator position. The measurement of water volume may then be limited to definite tests of output. For exact measurements of the losses it must be assumed that the fall remains constant within the region of outputs used for the determination of losses, and it is also assumed that it is possible to read the indicator with absolute precision; that means that the scale has fine divisions and that there is no lost motion. Since, however, the connection between the indicator scale and water volume is not a linear one, a large number of the points at small outputs must be plotted in load tests so that the curve $N_m$ line could be plotted as a function of indicator positions with sufficient clearness. (*Über Leistungsmessungen an Turbinen auf elektrischem Wege*, Dipl.-Ing. A. Strickler, *Bulletin, Schweiz. Elektrotechnischer Verein*, vol. 6, no. 3, p. 33, March 1915, 8 pp., 7 figs. *ed*).

### Internal Combustion Engineering

BELLEM AND BRÉGÉRAS AUTOMOBILE ENGINE

The article describes an improved type of the Bellem and Brégéras engine.

A special characteristic of the Bellem and Brégéras engine is that it can use, without preheating, even the least volatile fuels and can start on ordinary kerosene. In order to attain this important result, the inventors have had recourse to the use of injection and to atomization under very strong suction. At each suction, a certain amount of liquid is carried by a pump into a special atomizing valve which opens only after the piston is down a certain part of its stroke, creating a considerable vacuum in the cylinder. Immediately after this, carburetted air is admitted, the rest of the cylinder volume being filled up with pure air through a second admission valve.

The difficulty which the inventors encountered at first

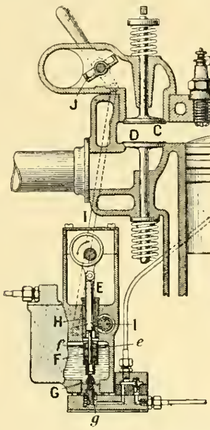



FIG. 3 BELLEM AND BREGERAS ENGINE

*A*, engine piston; *B*, atomizing valve; *C*, air admission valve; *D*, exhaust valve; *E*, rod of the pump piston; *e*, piston of the fuel feed pump; *F*, cylinder; *f*, cork protector; *G*, delivery flap valve actuated by the cylinder at the bottom of its stroke; *g*, valve spring; *H*, upper thrust block which can be governed by *I* and is connected with the air valve, *J*. (The pump takes in air at the bottom of the stroke, while the delivery occurs when the cylinder touches *G* and lifts it off its seat.)

was as to how to regulate efficiently the speed of the engine. In the original engine, this was done by a rather complicated device involving the use of a mercury column. In the present type shown in Fig. 3, this mercury column is eliminated and the regulation is effected by the construction of the feed pump which has a variable speed. As shown in the figure, it is of a reciprocating type with a plunger piston actuated by a connecting rod and eccentric, the cylinder centered about the piston with no connection to any fixed piece. Instead of any packing glands, there is a cork protector, which produces considerable friction between the cylinder and the piston. If not limited, the cylinder adhering to the piston, would move up and down with it without producing any pumping. Actually, however, two thrust blocks limit the motion of the cylinder, which latter naturally has to be deduced from the effective stroke of the pump. By varying the distance between the thrust blocks, one can vary the freedom of motion of the cylinder and thereby the effective stroke and output of the pump. It is very simple, of course, to change the distance between the thrust blocks and that is all the regulation which the new Bellem & Bregeras engine requires.

(*Perfectionnement au moteur Bellem et Brégéras*, A. W. *Omnia*, no. 445-28, p. 18, July 11, 1914, 1 p. 1 fig. *d*.)

### Mechanics

LATERAL FLEXURE OF HOLLOW PIECES, Henry Lossier

The article discusses the subject of lateral flexure of hollow pieces and shows how errors in calculation may be made in this connection.

Metal or reinforced concrete constructions often involve elements under compression, constituted by two parallel members *A*, united at equal intervals by cross-pieces *B*, so as to form a rigid structure. Fig. 4M shows, for example, an iron structure in which the members *A* consist of channel irons and *B*, Fig. N, of double pieces of sheet metal. In Fig. O, the members are angle iron and the cross-pieces, sheet metal, crossing each other at right angles. In either case, each unit carries with it at least two rivets. Fig. R shows a hollow element of length *L*, containing four equal rectangles and being under the action of an axial compression *P*.

It is usual to compute the stresses on such an element by considering it as being similar to a solid prism having the same moment of inertia and then taking its resistance to lateral flexure as being equal to that of a trunk or length *f*, taken between two consecutive cross pieces. Such a method of computation which would be all right if the cross pieces were supplemented by diagonal members (indicated in Fig. R by dotted lines), would be correct for this case only if the flexure of the element occurred as indicated in Fig. S, that is, with the axis remaining rectilineal all through the deformation. Actually, however, the flexure will occur by a lateral bending of the axis, as shown in Fig. T.

Because of such a deformation the following takes place:

*a* The normal stresses, of which the initial value for each member is $P/2$, undergo a decrease in the convex member $A'$ and a corresponding increase in the concave member *A*. This effect has its maximum value in the central trunks 2-2′;

*b* Because of the absence of diagonal stays and rigidity of the structure, *secondary flexures* occur both in the members and cross-pieces; these flexures, which are functions of the shearing stresses, reach their maximum values in the end trunks 1-1′.

The author recommends, therefore, for the calculation of such elements, the following formula and states that the fatigue of members will increase indefinitely as long as the stress *P* exceeds the critical value of $P_t$ equal to

$$P_t = \frac{\pi^2 EI}{L^2}\left[\frac{\alpha}{1 + \frac{I + 2I_A}{2.5n^2 I_A}\cdot\alpha}\right]$$

where *E* is the modulus of elasticity of material, *L* length of flexure, $I_A$ the moment of inertia of the member *A*, I the moment of inertia of the entire element,—that is the two members, *A*, $n = \frac{L}{f}$. $\alpha$ is a variable coefficient which is a function of the number of sections *n*, and has the following values:

| $n$ = | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ........ $\infty$ |
|---|---|---|---|---|---|---|---|---|
| $\alpha$ | 1.62 | 1.22 | 1.11 | 1.07 | 1.05 | 1.04 | 1.03 | 1.00 |

This formula is not new and its first member is simply the Euler formula, giving the bending resistance of a solid prism having a moment of inertia equal to $I$. The second part, which will be referred to later on as $k$, has a coefficient smaller than unity, towards which it tends as the number of sections increases, so that for $n = \infty$, $k = 1$. In other words, $k$ represents the ratio of the resistance of a hollow prism to that of a solid prism. The author recommends, therefore, the adoption of the following rule: *in a piece under compression, consisting of two parallel members connected into a rigid structure by cross-pieces located at equal distances from one another, the coefficient of permissible work is equal to the coefficient for a solid prism of the same moment of inertia multiplied by a coefficient k, less than unity, and given by the formula*

$$k = \frac{\alpha}{1 + \frac{I + 2I_A}{2.5n^2 I_A} \cdot \alpha}$$

From a numerical example, the author obtains curves shown in Fig. W, in which he uses for the upper curve (ordinary method) the Euler formula; next, the full drawn out curve represents what he would obtain with the formula proposed in this article, and finally the third curve is obtained by the Timoshenko formula (Annales des Ponts et Chaussées, May-June 1913), which the present writer uses in the form

$$P_{cr} = \frac{1}{\frac{L^2}{E.I.\pi^2} + \frac{f^2}{24E.I_A}}$$

obtained by neglecting the deformation of the cross pieces. This figure shows that with the exception of very small values of $n$, it gives results fairly close to those obtained by the Timoshenko formula which apparently tends to prove its correctness, as the Timoshenko formula is one of late date and apparent reliability. (*Etude du flambage des pièces. évidées*, Henry Lossier, *Le Génie Civil*, vol. 66, no. 10, p. 150, March 6, 1915, 2 pp., 8 figs. *t*).

Ball Bearings, Prof. J. Fischer-Hinnen

Investigation of the relation between axial and radial load on ball bearings.

Fig. 4 shows the state existing in an axially loaded bearing in a somewhat exaggerated manner. $R$ is the radius of the tread, $r$ radius of the balls, and $2a$ maximum distance between treads. It is further assumed that the distance $2a$ is by $\alpha$ per cent greater than the diameter of the balls, that is

$$a = \left(1 + \frac{\alpha}{100}\right) r$$

and therefore, because of the axial pressure $P_a$ there appears a pressure component, directed normally to the balls, $P_n$ of the magnitude

$$P_n = \frac{P_a}{\sin \beta}$$

The author further shows that the relation between $P_a$ and $P_n$ is determined by the following equation

$$P_n = \frac{2.2}{\sqrt{\alpha}} P_a$$

where 2.2 represents a coefficient which varies somewhat for different kinds of bearings (the author gives a table showing that), but may be taken to be equal to 2.2 for general purposes. This equation permits the determining of the additional pressure $P_n$ when the axial pressure $P_a$ and play $\alpha$ are known, and gives very interesting results. Thus, if the play is as large as 0.5 per cent, and the axial pressure is one third of the radial pressure, then

$$P_n = \frac{2.2}{\sqrt{0.5}} \cdot \frac{P}{3} = P$$

or the additional pressure is about 100 per cent of the radial pressure. Since, however, the manufacturers guarantee considerably smaller play, much greater additional pressures have to be looked for.

In the above connection, the author calls attention to the pitting to which the shaft on which a ball bearing is running is often subject, and which results in a surprisingly rapid wear of the shaft. Even though the gripping of the races against the shaft has been eliminated, very great wear of the shaft is nevertheless often the fact. It might have

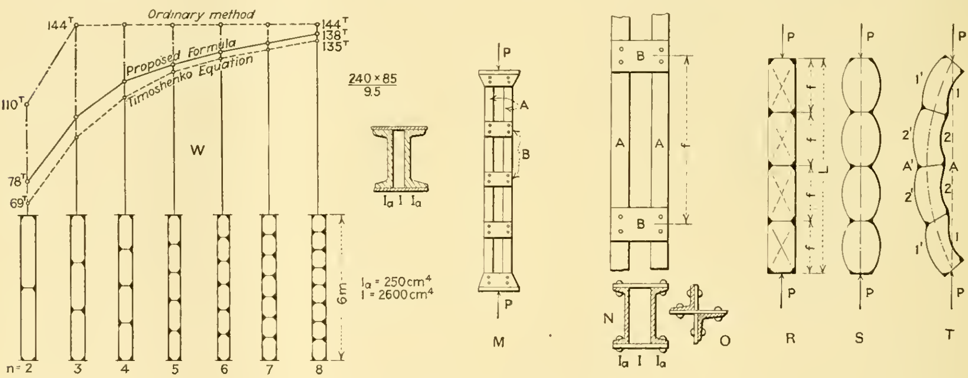



Fig. 4 Lateral Flexure of Hollow Pieces

been possible to ascribe it at first glance to the compression of material, but the low specific pressure at which ball bearings are run and the peculiar appearance of the surface of the shaft, which in places looks rusted and pitted, are against such an assumption. The author claims to have seen exactly similar conditions on shaft journals of engines not equipped with ball bearings and in which, after a run of only four or five hours, there appeared large rust spots and pits $^1/_{10}$ mm. deep.

In all of these cases it was found that the belt pulley was sitting pretty tight on the shaft. It would appear, therefore, that the cause of the wear of the shaft was electrolysis. In nearly all cases in which this phenomenon was observed, the engines were standing normally to the earth's meridian; that is, normally to the magnetic field of the earth, which, however, is not absolutely necessary for this effect because stray magnetic fields pass through the shaft anyway. It would appear, therefore, that in the boss, alternating current is generated. Since, however, the boss, because of its wedging, can have only a tilting motion in two directions,

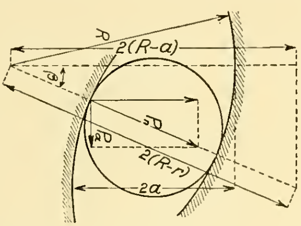



Fig. 5 Influence of Play on Distribution of Stresses in a Ball Bearing

there is, synchronously with the variation in direction of current, also a variation in the contact resistance; that is, the resistance at one change of direction of current is minimum and at another change is either maximum or infinite. We, therefore, have before us a kind of current rectifier which explains possible electrolytic action. If, on the other hand, the boss is loose on the wheel, both directions of current act at the same time and therefore there is no electrolysis. The same is the case with the races and ball bearings, and that is what this occasional excessive wear is due to. (*Über Kugellager,* Professor J. Fischer-Hinnen, *Elektrotechnik und Maschinenbau,* vol. 33, no. 12, p. 141, March 21, 1915, 2 pp., 3 figs. *tp*).

## Steam Engineering

### Evaporation Tests with Peat and Peat Coke as Fuels, H. Winkelmann

Report of evaporation tests with peat and peat coke, carried out on saturated steam locomobile and fire tube boilers.

The engines were used to drive peat-making machinery and were designed accordingly. The boiler, designed like a locomotive boiler, was equipped with a large box-shaped fire box, similar to the so-called Colonial locomobile boilers for burning straw, sugar factory refuse and corn stalks. The grate was designed suitably for this kind of fuel and very generously proportioned. Since the peat can be burned with comparatively small amounts of air [theoretically 4.9 lb. per lb. of peat at 15 deg. cent. (59 deg. fahr.) and 73.5 cm. barometric stand., with ignition temperature between 220 and 240 deg. cent. (428 to 464 deg. fahr.) and temperature of combustion about 800 deg. cent. (1472 deg. fahr.)] the free grate area is kept pretty low, so as to have as little excess of air as possible. In fact, with peat, it amounts to only 1.8 times to twice the theoretically required amount of air, just as with other kinds of boilers in which fuel of low heating values (and therefore in large amounts) is used, and particularly large fire doors are here provided. Data as to the fuel are given in Table 1.

The tests, full data of which are contained in the original article, have shown that even when pressed peat is used, with a comparatively high content of moisture, it is quite possible to obtain a boiler efficiency (referred to the fuel burned) of 60 to 62 per cent and this efficiency rises to 67 or 68 per cent when peat coke of much higher heating value is used. In tests where peat coke was used, the grate was reduced in accordance with its heating value. There is no doubt, however, that still better results would have been obtained if it had been possible to raise the grate duty still higher. On the other hand, however, the good burning of the fuel may be explained by the comparatively low rate of combustion.

TABLE 1 ANALYSIS OF PRESSED PEAT AND PEAT COKE

| Kind of Fuel. | Pressed peat. | | Peat coke. | |
|---|---|---|---|---|
| No. of sample | I. | II. | III. | IV. |
| | In per cent. | | | |
| Carbon | 40.3 | 38.2 | 82.2 | 81.8 |
| Hydrogen | 4.2 | 5.0 | 2.1 | 2.1 |
| Nitrogen | 0.7 | 0.8 | 1.1 | 1.0 |
| Oxygen | 28.4 | 30.4 | 5.2 | 5.2 |
| Sulphur | 0.6 | 0.4 | 0.5 | 0.5 |
| Water | 16.0 | 17.6 | 5.1 | 5.3 |
| Ash | 9.8 | 7.6 | 3.8 | 4.1 |
| Combustible matter | 74.2 | 74.8 | 91.1 | 91.6 |
| Calorimetric heating value in calories per kg./B.t.u. per lb. | 3080/5544 | 3110/5598 | 7128/12830 | 7015/12627 |

The author makes the following statement as to peat coke. It is a comparatively new material, produced in special coke ovens where, from each 30 tons pre-dried raw peat from 8 to 9 tons of coke are obtained, gas and tar being secured as by-products. The gas is used to heat the vertical coke retorts as well as to drive the engines, while from the peat tar are obtained gas and creosote oils, paraffine, methyl alcohol, pitch and sulphate of ammonia. (*Einige Verdampfungsversuche mit Torf und Torfkoks,* H. Winkelmann, *Zeits. für Dampfkessel und Maschinenbetrieb,* vol. 38, no. 10, p. 82, March 5, 1915, 2 pp. *e*).

## Strength of Materials and Materials of Construction

### Mechanical Properties of Teak Wood, A. Weiskopf

The article reports an investigation of the mechanical properties of teak wood, carried out in the laboratory of the Hannover Car Company, in Hannover-Linden, Germany. The paper gives some data as to the manufacture of teak wood articles and its general properties, and then proceeds to report the data obtained from the investigation itself.

The extensive and growing introduction of teak wood for use in car construction in Germany made it desirable to obtain precise information as to its mechanical properties. The present investigation was somewhat curtailed in its scope by the coming of the war. These investigations covered compression strength, bending strength and tensile strength of the wood. For compression strength tests (Schenck testing machine) cubes 7 x 7 x 7 cm. or 10 x 10 x 10 cm. were used; for bending tests (same machine) bars 80 cm. long

and 8 x 8 cm. in cross-section; for tensile tests (Tarnogrocki testing machine) test bars 50 cm. long and 1 x 1 cm. in cross-section. All the tests were made on teak wood of two kinds, Indian and Java.

Separate tests were made on artificial drying of teak at a temperature of 50 deg. cent. for periods up to 40 days. The results obtained are tabulated in the original article and show that the loss in weight for a period of drying of one day amounted to 2.3 per cent. Then for the next two or three series of two to three days each this loss varied from 2 to 2.8 per cent, with a considerable decrease in the later stages of drying, so that in the last ten days of the test, it amounted only to 1.2 per cent, the total loss in weight after 40 days being 15.7 per cent. As regards the change in volume, no change was found in the length (in the direction of fibre, but parallel to the year rings), but 1.4 per cent was found in the width (tangential to the year rings), and 1.1 per cent in thickness (radial to the year rings).

The data of compression tests are given in the original article in the form of a table and two curves, one for Indian and another for Java teak. This table is not reproduced here. There the stress in compression was applied in three directions, that is, in the direction of the fibre; normally to the fibre and radially to the year rings, and finally, normally to the fibre and tangentially to the year rings. It was found that the Java teak is stronger in compression than the Indian teak and can stand stresses as high as 479 to 498 kg/qcm. For the sake of comparison, the author quotes several kinds of other European woods, such as oaks, with a maximum strength of 327 kg/qcm, and foreign woods, Jarrah 321, Bongosi 599, Njabi 503 and Bang 444 kg/qcm. (the last three are grown in Kamerun, Africa).

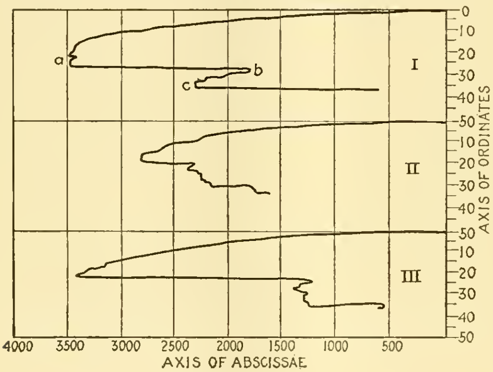



Fig. 6 Bending Tests on Indian Teak Wood

The bending tests have been carried out on the same machine as the compression tests; their data are reproduced in a table and again in two sets of curves, of which the curves in Fig. 6 for Indian teak are here reproduced. The axis of the abscissae indicates loads in kilograms and the ordinates, bending in millimeters. In curve I, at the load of 500 kg., there is a deflection of 1 mm., while at 3000 kg. the deflection is already as high as 11 mm. At point *a* the maximum stress is reached, at a breaking load of 3450 kg. At that point the test piece is ruptured, as is indicated by a loud crack.

In addition to that, with the pressure radial to the year rings, the upper part of the wood in one of the year rings on one-half of the test bar became loose, so that the lower part of the bar appeared, at the conclusion of the test, to be pushed out forward. Next we see a brief backward run of the line; then a further bending of the bar and finally a longer backward motion of the line up to point *b*, to which corresponds a load of approximately 1720 kg. From here on, the test bar again becomes able to take up a larger load, which gradually rises at point *c* to about 2290 kg., after which a new backward motion of the line begins. As far as the useful strength of the wood is concerned, the diagram is of importance only up to the point *a*, but the rest of it is also of interest for the estimation of the quality of the wood in as far as it shows that the test bar, even at maximum load, does not break down entirely, and that rather only a part of the fibre is destroyed, while the other part still holds together and offers further resistance.

The results of tensile strength and rupture tests are reported in a table, both for Java and Indian teak wood. Such tests are rather hard to carry out because there is considerable difficulty in the preparation of the test bars, as it is difficult to cut them in such a manner that in the reduced cross-section bar the longitudinal fibres run parallel to the longitudinal axes. No tests have been made on the behavior of the wood under sand blasts. (*Untersuchungen von Teakholz in der Hannoverschen Waggonfabrik A.-G., Hannover-Linden,* Dr. techn. A. Weiskopf, *Glasers Annalen für Gewerbe und Bauwesen,* vol. 76, no. 4, p. 68, 904, February 15, 1915, 7 pp., 8 figs. *e*).

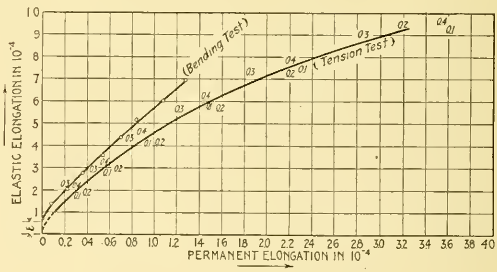



Fig. 7 Elastic Properties of Cast Iron

Bending Elasticity of Cast Iron, Professor Akimasa Ono.

The article presents data of tests on tensile, compressive and bending strength of cast iron, and discusses the bending elasticity of cast iron. It also treats of the permanent set produced in cast iron by bending as well as the relation between the elastic and permanent sets in bending or tension. In his introduction, the author briefly summarizes the results of preceding investigations of Kármán, Bach, Pinegin, Herbert and Schöttler. The tests were carried out in the machine laboratory of the University of Fukuoka, on a 13,000-kg. Mohr and Federhaff testing machine.

The data of the tensile and compression tests are presented by the author in a number of tables. Among other things, he found that both the total and the permanent elongation, occurring at a certain stage of loading, materially increase with the number of repetitions, while the elastic elongation appears to have a much more regular behavior. Tables 2 and 3 respectively give a compilation of results obtained

from four tests each. If the equation $\varepsilon = \alpha.\sigma$ is used, in order to present the relation between $\sigma$ and $\varepsilon$, one obtains from the above experimental data the following equations:

For tensile strength:

$$\varepsilon = \frac{1}{2690700} \cdot \sigma^{1.193}$$

and for compression strength:

$$\varepsilon = \frac{1}{1320800} \cdot \sigma^{1.049}$$

The author shows that the curves obtained from these equations nearly coincide with a curve obtained experimentally, the latter representing a purely elastic behavior of the material investigated.

From this, the author proceeds to explain his method of calculating the bending moments from the data of tensile and compression strength tests. He has also made a number of bending tests on test bars prepared from the same piece of cast iron from which the samples for the tension and compression tests were taken. In the preparation of all these samples, great care was taken to obtain a sound casting. The method of carrying out the test and the arrangements for taking fine readings is fully explained in the original article and the data of tests given in tables.

The author finds that the law $\varepsilon = \alpha\sigma^m$ is not so fully adhered to in tension as to permit its being used for a reliable expression of the elastic behavior of the material investigated. He also found that the constants $\alpha$ and $m$, in the above equation for elasticity, are different from those which Bach found for various test bars made of cast iron. Next he determined graphically, on the basis of the data obtained from tensile and compression tests, the relation between the moment of bending and the elongation of the extreme outward layer in tension of the bar under bending. The curves obtained in this manner were used in order to determine the elongation of the above referred to layer of fibres corresponding to every moment of bending. Naturally, however, this graphically determined elongation did not fully coincide with that actually observed probably because of unequal cooling of the metal.

A very remarkable fact was found that the permanent elongation observed in the extreme fibres and under tension during the bending test was considerably slighter than during the tension test. To illustrate this fact, two curves (Fig. 7) were plotted, showing the relation between the elastic and permanent elongation in tension and bending, and the comparison of these lines indicates the presence of an initial stress as well as the rise of additional stresses. Strictly speaking the data of tests, both on elasticity and on strength generally, cannot be clearly understood without taking into consideration these internal stresses.

Finally, the bending tests have confirmed the statement made by Schöttler to the effect that the permissible bending stress, $k_b$, is to $k_z$ (permissible stress in tension) in a ratio different from $\frac{K_b}{K_z}$ (strength in bending and tension, respectively). (*Die Biegungselastizität des Gusseisens*, Professor Akimasa Ono, *Memoirs of the College of Engineering, Kyushu Imperial University, Fukuoka, Japan,* vol. 1, No. 2, p. 111, 1915, 54 pp., 13 figs. *te*).

TABLE 2 VALUES OF $\sigma$ AND $\epsilon$ FROM FOUR TENSION TESTS

| $\sigma$ kg/cm² | $\epsilon$ (observed) $10^{-4}$ | $\epsilon$ (calculated) $10^{-4}$ | Difference between calculated and observed values | |
|---|---|---|---|---|
| | | | $10^{-4}$ | in per cent of observed elongation |
| 95.5 | 0.900 | 0.856 | −0.044 | −4.9 |
| 191.0 | 1.900 | 1.956 | +0.056 | +2.9 |
| 286.5 | 3.029 | 3.173 | +0.144 | +4.8 |
| 382.0 | 4.308 | 4.473 | +0.165 | +3.8 |
| 477.5 | 5.755 | 5.837 | +0.082 | +1.4 |
| 573.0 | 7.399 | 7.255 | −0.144 | −1.9 |
| 668.5 | 9.229 | 8.719 | −0.510 | −5.5 |

TABLE 3 VALUES OF $\sigma$ AND $\epsilon$ FROM FOUR COMPRESSION TESTS

| $\sigma$ kg/cm³ | $\epsilon$ (observed) $10^{-4}$ | $\epsilon$ (calculated) $10^{-4}$ | Difference between calculated and observed values | |
|---|---|---|---|---|
| | | | 1−0⁴ | in per cent of observed compression |
| 97 3 | 0.938 | 0.922 | −0.016 | −1.7 |
| 194.6 | 1.883 | 1.908 | +0.025 | +1.3 |
| 291.9 | 2.878 | 2.919 | +0.041 | +1.4 |
| 389.2 | 3.918 | 3.947 | +0 029 | +0.7 |
| 486.5 | 4.998 | 4.988 | −0.010 | −0.2 |
| 583.8 | 6.028 | 6.039 | +0.011 | +0.2 |
| 681 1 | 7.148 | 7.100 | −0.048 | −0.7 |
| 778.4 | 8.213 | 8.167 | −0.046 | −0.6 |
| 875.7 | 9.283 | 9.241 | −0.042 | −0.5 |

# ENGINEERING SOCIETIES

## AMERICAN SOCIETY OF MARINE DRAFTSMEN

*Journal, vol. 2, no. 1, April 1915, Washington, D. C.*

The Diesel Engine, Dr. Paul Rippel
Machinery Arrangements, R. Entriken
Marine Engine Design, E. T. Cunliffe
Hulls for Aeroplanes, H. C. Richardson, U. S. N. (abstracted)

### Hulls for Aeroplanes, H. C. Richardson

The paper reports tests on various hulls for aeroplanes, made at the Naval Model Basin since 1911.

The conditions of operation of aeroplane hulls are materially different from those met with in ordinary displacement work. In the first place, the speeds at which these hulls are used are very high,—from 45 up to and in excess of 60 miles per hour. Then, after a speed of 20 miles per hour is obtained, it is possible to control the trim of the hull so that it can be forced through the water at a different inclination than it would assume naturally. The most impor-

tant difference, however, is that while the load carried by the hull decreases practically as the square of the speed, this decrease in load is also a function of the angle of the machine with the horizontal and is, therefore, subject to change with change of trim.

The author produces several curves, together with the respective forms of the hulls, showing for typical conditions, the curves of resistance for one-quarter size models, run at various speeds. It has been found that in ordinary displacement conditions, the resistance mounts very rapidly after a speed of about 3 miles per hour, whereas the same model, run at fixed trim and displacement corresponding to speed, runs a little harder up to 3 miles per hour, but from that point on, the rate of increase of resistance gradually falls off and the resistance reaches at about 13 miles per hour, the value of 6.1 lb. as compared with 22 lb. under displacement conditions. From that on, the resistance rapidly falls off to practically nothing at 19 miles per hour, which is the speed corresponding to that at which the wings do the lifting. As regards step-type hulls and their tendency to "porpoise" under aeroplane conditions, a number of experiments have demonstrated that the ventilation of the step is not absolutely necessary but very desirable, as it allows of planing at much lower speeds than is practicable if no ventilation is provided.

The first series of experiments was worked out in January 1912. One of the earliest experiments made was that with the single hull of a semi-circular section, having ogival ends. It was expected that as the resistance at low speeds was primarily due to wetted surface, which became an important factor at high speeds because of the lift of the wings, a minimum wetted surface for displacement required might give good results. This proved to be correct at low speed, but when attempts were made to run this model at intermediate and high speeds, a new effect was found and the model, instead of having its resistance decrease as the speed increased, showed a remarkable increase in resistance and a strong tendency to settle back into the water, these effects becoming more and more pronounced as the speed increased. At about 9 knots, this model tried to submerge itself and at the same time lifted sheets of spray clear of the surface of the model basin, and thus demonstrated in a very exaggerated manner the difficulties to be met with when curved surfaces are exposed to the flow of water at high speed.

In another model, this difficulty was very much reduced by trimming it at the stern, although the resistance still remained high. The model tried on an even keel and trimmed at the stern showed a behavior better than any of the models previously tried. It was predicted that in a full sized model, a sharp bow would be unable to stand the thrust of the propeller and would tend to nose on that account, even though the center of gravity was placed sufficiently far behind the center of buoyancy to give a righting couple equal to the nosing moment of the thrust of the propeller when planing. This is what happened, but subsequent experiments showed that the reason for the nosing was due to the "heavier tail" and to the fact that the center of pressure under way was so near the stern that it was behind the center of gravity and thereby caused the model to nose. Many experiments with different shaped bows, flat, concave, convex and one of a freak corrugated type, showed that the shape of the bow could be varied in a wide range without seriously affecting the resistance.

An experiment was made to determine whether two models run as catamarans interfered with each other and it was found that at moderate speeds, the interference was slight and unimportant while at high speed there was practically none. Experiments with the ordinary Curtiss type and the beaver tail type showed that if the tail end of the hull was much behind the propeller position, it was impracticable to get the machine to leave the water because of the strong nosing tendency present at high speed. It was also found that such restricted length of hull would allow the machine to turn over backwards and as it was considered undesirable to use a tail float, it became necessary to obtain additional buoyancy at the stern in some manner which would not interfere with the getting away at the surface.

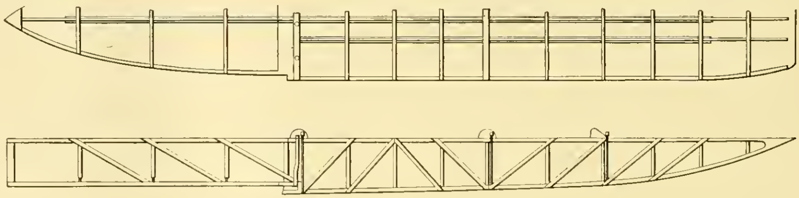


Fig. 8 An Aeroplane Hull of Fair Efficiency

As a result, the model was run with rising fore and after body. This model behaved very well at high speeds, but the suction under the curved rising afterbody was so great as to cause excessive squatting, with the result that the propellers were brought dangerously near the water, which made this type unsatisfactory. To eliminate this difficulty, the same form of bow was used but the stern was tapered as shown in Fig. 8, this giving a sort of flat-iron stern and in order to break the suction around the stern, a step was formed at the side as well as under the bottom of the hull. This model behaved well at high speeds and satisfactory at low speeds on an even keel and on a straightaway course, but when an effort was made to turn the machine running at moderate speed, the water suddenly closed around the steps and gripped the left side of the tail of the hull. This effect grew with such sharpness that it spilled the machine over to its starboard bow and plunged the right wing into the water so that the machine was kept from capsizing only with the utmost difficulty. The above experiments emphasize the very powerful effect of suction.

As a result of the above work, a form of hull has been derived (not described) which appears to have decided advantages over those already in use in the Navy, so far as resistance on the surface and in the air is concerned.

The article contains tables showing the computation of the head resistances in water in detail for each of the models tested, as well as the frictional resistance, residual resistance and total resistance. The author comes to the following conclusions:

*a* The step should be close to the position of the center of gravity, to eliminate a nosing tendency, to facilitate change of trim while planing and to avoid change of balance when getting away or landing.

*b* Hollow V sections keep the spray down, cut the water more easily and cleanly, plane better, and greatly reduce shock on landing or when ploughing through broken water, and practically eliminate the necessity of shock absorbers. But in practice, care must be exercised to keep this sharp keel clear on side landings or when running on the nose, as this keel tends to bite suddenly and steer strongly.

*c* A shallow step is sufficient, but ventilation is essential to facilitate the breaking of suction effects.

*d* The bottom forward of the step should be inclined to the axis of the machine, but

*e* The inclination must not be so great as to cause planing before the controls are effective, and this is particularly necessary when running before the wind. If the planing of the hull is too pronounced, the machine rises to the surface with but very little control available to maintain balance, and when running before the wind this is more apt to occur due to the higher water speed necessary before the machine can take the air, yet sufficient reserve planing power must be available to enable planing without wing lift, or the hull will drive so hard as to be impossible to get away. These requirements are contradictory and call for a compromise.

*f* The bottom abaft the step should rise strongly as this favors a steepening of the planing bow before suction is eliminated, and gets the tail well clear when planing begins. (18 pp., 9 figs. *eA*).

## AMERICAN SOCIETY OF NAVAL ENGINEERS

Turbine Electric Propulsion of a Battleship Compared with Other Means, P. W. Foote, U. S. N.
Motor Cylinder Lubrication, G. S. Bryan, U. S. N. (abstracted)
Tests of Matanuska Coal, U. S. S. "Maryland"
Description of the Repair Plant of the U. S. S. "Vestal", L. J. Connelly, U. S. N.
The Foundry Use of Non-Ferrous Scrap Metals, F. M. Perkins, U. S. N.

### Motor Cylinder Lubrication, G. S. Bryan

The article discusses the conditions under which lubrication in the cylinder of an internal combustion engine takes place and the characteristics of motor cylinder oils which determine the suitability for these conditions.

Trouble with lubrication in an engine can be traced to the following causes: poor design of engine and lubrication system, poorly refined oil, the improper supplying of oil to the cylinders, and oil of good quality but not suited to the particular type of engine. Trouble from any of the first three causes is unusual, while in the fourth case it can be easily corrected by using a different oil.

The action of heat on oils is indicated by two properties, the flash point and the fire point. It is important that the flash point shall be higher than the temperature of the inner surface of the cylinder, as otherwise the vapor given off by the oil will prevent it from adhering to the walls. It is, however, an old theory that was never founded on solid facts that the high flash point is a necessity in the motor oil or the oil would burn up without giving any lubrication. The author claims that the point was overlooked, that when we have a maximum temperature of gas in the cylinder of 2700 deg. fahr. and an average temperature of 950 deg. fahr., an oil with a flash point of 450 deg. will offer a little more resistance to burning than one with a temperature of 350 deg. Either oil will burn if kept for any length of time in contact with the hot gases, but lubricating oil does not burn rapidly and the time given for it to burn in a motor cylinder is very short. A thin film of oil smeared on a hot piece of iron or steel (300 deg.) will burn for several seconds if ignited. Few motors, however, ever run at less than 120 r.p.m., and at this rate, the average point of lubricated surface of the cylinder wall would be exposed to the action of the flame for only a quarter of a second, and therefore there is no danger of all the oil film being burned in so short a time, although some of it is burned, no matter whether the flash point is 300 or 500 deg. fahr.

A source of trouble is also the formation of carbon deposits in the cylinder, upon which subject a good deal of misinformation has been published. What is ordinarily known as carbon in the cylinders nearly always contains something else in greater or less quantity; for instance, rust and small particles of iron are nearly always found. In automobile motors a large percentage of dust is generally present and in marine motors, salt is a common constituent.

An oil that was considered unsatisfactory on account of a large amount of carbon formed in it has been recently investigated at the Naval Engineering Experiment Station and a chemical analysis of the oil from the crank casing that was supposedly full of carbon, gave results as follows:

| | Per cent |
|---|---|
| Free oil | 15 |
| Water | 12 |
| Rust | 11 |
| Salt from sea water | 58 |
| Decomposed oil | 2 |
| Carbon | 1 |
| Foreign matter | 1 |

Carbon may exist in a motor oil in two forms—as free carbon held in suspension or as a chemical part of the hydrocarbon compounds which go to make up the oil. Under the intense heat in the cylinder, the inner surface of the oil film is vigorously affected and in the absence of the air necessary for burning, three things might happen: *first*, the compounds may volatilize without decomposition; *second*, the compounds may decompose with the formation of free carbon and hydrogen; *third*, the compounds may decompose with the formation of other hydrocarbon compounds of a different nature. In the first case, the products will escape as gases; in the second, the carbon will be in a very fine state and be mostly blown out with the exhaust. Only when the compounds of decomposition, classed under the third case, form a gummy deposit, will the carbon stick to it and tend to make such a deposit thicker and harder and finally form the hard "carbon deposit." Where the compounds break up into new compounds, the nature of these new compounds will depend upon the properties of the oil. The oil that

will give the best results is not necessarily one that will form the least carbon but the one that will form the least carbon in the cylinders.

Oils made from Southern asphalt base crudes have shown themselves to be much better adapted to motor cylinders as far as their carbon forming proclivities are concerned, than are the paraffine base Pennsylvania oils. The carbon formed from the latter is as a rule extremely hard and clings to the metal surfaces, while that of the former is soft and can be easily wiped off any surfaces upon which it may be deposited. The cause of this lies in the fact that the paraffine oil bases are generally composed of paraffine series of hydrocarbons, while the asphalt base oils are composed mainly of the ethylene and naphthene series and one of the characteristics of these two series as compared with the paraffine series is their tendency to distill without decomposition. The lighter grades of motor oil are nearly equal in their properties, but in order to get oils with a high viscosity in the paraffine brands, it is necessary to compound the light oils in different proportions with heavier cylinder oil and it is the presence of this latter that is responsible for most of the gumming. The color and specific gravity of lubricating oils sometimes indicated in advertisements of oil companies are of no particular value to the consumer, although an expert can, from the specific gravity, in conjunction with the flash point, determine from what particular kind of crude, the straight oil is made. (14 pp., 1 figs., *H*).

## AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

*Journal, vol. 1, no. 3, March 1915, New York, N. Y.*

An Aneroid Calorimeter, H. C. Dickinson and N. S. Osborne (abstracted)
The Specific Heat and Heat of Fusion of Ice, H. C. Dickinson and N. S. Osborne (abstracted)
A Standard Basis for Finding the Fuel Economy of Steam-Driven Ice Manufacturing Plants

An Aneroid Calorimeter, H. C. Dickinson and N. S. Osborne.

The paper describes a special calorimeter used by the author for the determination of the specific heat and heat of fusion of ice. (See next abstract.)

The most important feature of this calorimeter is the use of a shell of copper enclosing the specimen under investigation, the copper acting as a calorimetric medium for the transmission and distribution of heat developed in an electric heating coil which is built into the shell. Temperature changes in calorimeter and contents are measured by means of an electric resistance thermometer, likewise built into the shell. The calorimeter is suspended in the air space within an enclosing metal jacket while the multiple thermo-couples are distributed about the surface of the calorimeter to indicate at any instant the difference between the average temperatures of the surfaces thus enabling the corrections for thermal leakage between calorimeter and its surroundings to be controlled and measured.

The aneroid calorimeter, as this apparatus is called, is claimed to combine the following characteristics: it is applicable to both solids and liquids, even under high pressure; the same instrument, without changes, can be used over a wide range of temperature and by suitably adapting the jacket and the liquid used therein, this range can be extended over the region from the lowest temperature attainable up to +200 deg. cent and higher; the heat capacity of the calorimeter and contents can be measured over small temperature intervals, thus approximating the heat capacity at a definite temperature; troublesome corrections, due to the evaporation of the calorimetric liquid and to the energy supplied by the stirring device, are eliminated.

A series of check experiments on the specific heat of water shows the order of reproducibility of results which can be obtained with this calorimeter to be 1 part in 2,000. Measurements made at temperatures between 0 deg. and 40 deg. cent. gave results which agree to within the limits of experimental accuracy with the unpublished results of a long series of experiments made in the usual form of stirred water calorimeter. The results are also in satisfactory agreement with the most probable values deducible from the data of the most careful investigations published by other observers.

The original article gives the details of design and a diagram of circuits used, as well as tables of calibration of thermometers by the calorimeter. (27 pp., 11 figs.)

The Specific Heat and Heat of Fusion of Ice, H. C. Dickinson and N. S. Osborne.

The paper describes one of a series of investigations undertaken, at the request of the refrigeration industries, by the Bureau of Standards, at Washington, D. C., for the determination of constants which are of fundamental importance in the design and operation of refrigerating machinery. It refers particularly to the specific heat and heat of fusion of ice. A previous determination of the heat of fusion of ice made at the Bureau of Standards was published in 1913, at the time of the meeting of the Third International Congress of Refrigeration in Chicago. At that time, it was stated that the results presented were subject to a slight uncertainty on account of the lack of adequate knowledge of the specific heat of ice near the melting point. This has been the subject of the work described in the present article.

After a brief reference to previous work and a description of the calorimetric method employed (the aneroid calorimeter described in the preceding abstract was used), the authors proceed to the description of the material and the preparation of the samples, a matter of great importance in view of the fact that even small amounts of impurities are liable to cause a considerable increase in the apparent heat capacity due to incipient melting of portions of the ice. The experimental procedure used and methods of calculation are described in some detail and the experimental results, giving the specific heat of ice, are presented in several tables and diagrams, the tables expressing the observed mean specific heats of the several samples with reference to the initial and final temperatures $\theta_1$ and $\theta_2$ of the respective experiments ($S_m = \frac{H_2 - H_1}{\theta_2 - \theta_1}$ where $H_2 - H_1$ represents the total heat per gram over the interval $\theta_2 - \theta_1$).

A preliminary plotting of the observed mean specific heats indicated that the curves of specific heat were asymptotic to a straight line, the departure from which was apparent on the above temperatures varying from —8 to —2 deg. for various samples, which appears to corroborate the observation of Smith, that the specific heat of ice tends toward constancy as the impurities in the ice are reduced. As regards

the relation between apparent specific heat of ice and dissolved impurities, it has been assumed that the measure of the departure of the specific heat of a specimen of ice from a linear function of the temperature depends upon the degree of purity. While the results upon four samples of ice, all of high and yet different degrees of purity, agree with this assumption, it does not necessarily follow that the assumption is substantially correct and it is quite possible that the relation of the specific heat of pure ice to the temperature is other than linear, perhaps rapidly increasing near zero.

It has been found that at a given temperature, $\theta$, between —40 and —2 deg. for the purest ice experimented on the specific heat, in 20 calories per gram per degree is represented within the limits of experimental accuracy by the equation

$$S = 0.5057 + 0.001863\,\theta$$

and that from —2 to —.05 deg., the specific heat for pure ice does not depart from the value given by the above equation by more than $\frac{0.004}{\theta^2}$. The specific heat of impure ice at a temperature $\theta$ above —40 deg. is greater than that of pure ice by $lL/\theta^2$, where $L$ is the heat of fusion, and $l$ the initial freezing point.

The value found for the heat of fusion of ice is 79.76, *20 deg. calories per gram*, which is within $\frac{1}{4000}$ of the value previously determined at the Bureau by the different method, employing a stirred water calorimeter.

The original article gives the table of total heat of ice and water at temperatures for ice from —20 to + 32 deg. fahr. and for water from +32 to 100 deg. fahr. (29 pp., 7 figs. *e*).

### CLEVELAND ENGINEERING SOCIETY

*Journal, vol. 7, no. 4, January 1915, Cleveland, O.*

An Example of Novel Shore Construction and General Talk on Jetty Action, Walter P. Rice

The Useful Recovery of Heat Losses in Internal Combustion Engines, J. B. Merriam (abstracted)

Founding as an Art and Adjunct to Engineering, Thomas D. West

The Useful Recovery of Heat Losses in Internal Combustion Engines, J. B. Merriam.

The paper describes a new method of recovering heat losses in internal combustion engines, and also discusses the causes of certain limitations in water cooling in the present engines.

It is a well-known fact that, with an ordinary water supply, an engine will work satisfactorily when the temperature of water is around 150 deg. fahr., but if the temperature of the water in the jacket is allowed to rise, the cylinder will burn or score even before the jacket water reaches, say, 250 deg. The elements which affect the flow of heat from the inside surface of the combustion chamber to and into the water are:

*First.* The difference in absolute temperature or the relation of the two temperatures to the absolute zero point. This is measurable, but not sufficient to cause a disastrous interference to the flow of heat which takes place somewhere between the surface of the combustion chamber and the water.

*Second.* The amount of surface exposed: in an engine already built it is constant, that is, it does not change with the change of water jacket temperature from 150 deg. to 250 deg., and therefore cannot affect the results when such a change takes place.

*Third.* The time of exposure: after the revolutions of the engine have been determined, it also becomes constant.

*Fourth.* The unit of resistance to the flow of heat: this appears to be the only element subject to change when the jacket water temperature materially rises.

To find out why it changes, the author refers to the familiar experiment of heating water in a rough cast iron vessel. It is there found that no visible change occurs below 140 deg. fahr., but above it, small bubbles are formed which adhere to the surface of the iron. These bubbles increase both in number and size with rise of temperature, and by the time the water has reached 200 deg., the inside surface of the vessel seems fully covered with bubbles.

The secret of the entire difficulty of running an engine

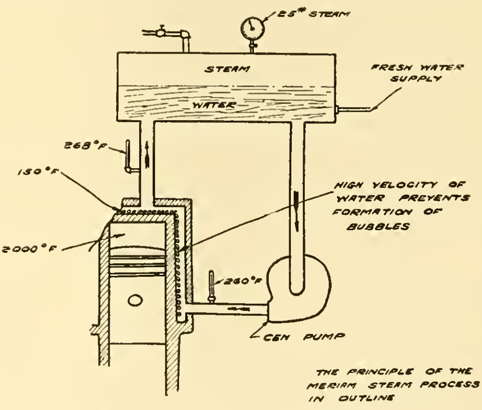



Fig. 9 The Merriam System of Recovery of Heat Losses in Internal Combustion Engines

with the water jacket temperature above 150 deg. lies in this formation of bubbles, since, if any portion of the surface continues to increase in temperature after the formation of the bubbles, spheroidal action takes place and thus constitutes a critical interference to the flow of heat, or, which is equivalent to it, to the cooling effect of the water.

It has been further observed that each of these bubbles increases in size and finally breaks away, and a new bubble rapidly forms on the same spot, which is somewhat hotter than the metal surrounding it, because it has been protected from contact with water by the previous bubble. If, however, the water is disturbed in the vessel so as to put it in motion, the bubbles break off while much smaller, the size of the bubbles decreasing as the velocity of the water is made to increase. Through these facts, the author comes to the conclusion that the formation of these bubbles and their adherence to the cylinder walls could best be prevented by very high velocities of the jacket water, which would permit both the using of higher temperatures of water and producing as a by-product a considerable amount of steam which can be employed for various purposes.

A series of experiments were made on a 150 h.p., 4-cylinder, 12¼ x 14 in. Bruce-Macbeth type engine, fully equipped

with thermometers, flow meters and gages, and a centrifugal pump which was used to force the water at high velocity through the cylinder jackets. The velocity of the water was maintained at from five to ten times that ordinarily used. The measurement was substantially as shown in Fig. 9. With this engine, it was found that it required less than 30 minutes to bring the system up to 10 lb. steam pressure, while in the other tests, the pressures have been increased to 50 lb., which is equivalent to a temperature of 297 deg. If an enclosed cooling system be used, as shown in the above figure, and only steam allowed to escape, then all of the water used must eventually be turned into steam and the entire amount of heat of the fuel, usually referred to as lost to the jacket water, will be fully recovered in the heat units restored in the steam. This appears to be actually the case. With a well designed exhaust-gas boiler, one-half of the 35 per cent of the total heat units of the fuel lost to the exhaust can be recovered and added to the 35 per cent recovered from the water jacket, which will give approximately 50 per cent of the total heat units of the fuel available in the form of low pressure steam. An exhaust boiler, or any low pressure or heating boiler, can be included as a part of the system.

At the same time, the efficiency of the engine as shown by

TABLE 4 RESULTS OF TESTS OF GAS ENGINE WITH WATER COOLING AT HIGH SPEED IN THE JACKET

| | ¼ Load | ½ Load | ¾ Load | Full Load |
|---|---|---|---|---|
| Brake h.p. | 43 | 77 | 112 | 151 |
| | 17.58 | 12.58 | 10.35 | 9.58 |
| Gas h.p. hour | 14.3 | 11.4 | 9.78 | 9.28 |
| Temperatures, deg. fahr.: | | | | |
| Water supply | 52 | 52 | 52 | 52 |
| Inlet to cylinder | 253 | 253 | 253 | 253 |
| Outlet cylinder | 260 | 262 | 266 | 267 |
| Exhaust manifold | 256 | 257.5 | 260 | 260 |
| Steam pressure, lb. | 17.5 | 17.75 | 18 | 18 |
| Lb. of water evaporated per h.p. hour | 7.3 | 5 | 4.3 | 3.7 |

Table 4, is also improved by this process, due to the higher temperature of the cylinders. The small figures show the gas consumption of the same engine when running with the cylinders at ordinary temperature. No difficulties or detrimental effects have been experienced when operating an engine under this process at maximum load and with the water jackets under full steam pressure and temperature. On the contrary, the resultant condition is favorable, since the water passes through the cylinder at such high velocity that the difference between the temperature of entering and outgoing water is less than 15 deg. and the cylinder and all parts of the engine are maintained at a uniform temperature. This temperature also remains constant irrespective of the load, as it is determined entirely by the steam pressure carried on the system. Another advantage claimed for this system is that the thermal efficiency of the engine is improved so that the fuel consumed is at least two per cent less at maximum load and fully 15 per cent less at one-quarter load as shown by tests.

A brief list of references on matters connected with the subject of the paper is appended to the original article (13 pp., 4 figs. *deA*).

## ENGINEERS' CLUB OF PHILADELPHIA

*Proceedings, vol. 32, No. 1, January 1915, Philadelphia*

Air Conditioning, J. Irvine Lyle (abstracted).

Bituminous Coals, Predetermination of their Clinkering Action by Laboratory Tests, F. C. Hubley.

Reinforced Concrete in the Edison Fire, Percy H. Wilson.

### Air Conditioning, J. Irvine Lyle

The paper discusses present methods of air conditioning and then describes a number of applications of air conditioning installations. Its interest is in showing the wide field of application for this kind of apparatus and the valuable results which may be obtained with it.

The Lord & Taylor department store building, at Thirty-ninth Street and Fifth Avenue, New York City, is a good example of the application of air conditioning to a department store. With 82 deg. outside, inside the temperature was only 73 deg. and it felt cool and invigorating to a person coming in from the street.

There are many industrial plants in addition to textile mills where the question of humidity is of greatest importance. Four years ago there was not a bakery in the United States that was equipped for air conditioning. Today there are thirty odd bakeries having control of humidity in their dough-rooms, so as to regulate the germination of the yeast and prevent the gases generated in the raising process from being given off. On a commercial basis, figured on the continuous operation of a bakery, it gives about fifteen more loaves of bread per barrel of flour and makes whiter, better bread. The same applies to candies. Hard candies require low temperatures and low humidities for proper drying. For chocolates, low temperature must be provided in order to congeal it.

Control of humidity conditions is still more important in the case of macaroni. If dried too quickly, it will break all to pieces when the housewife gets it, and if dried too slowly, it is liable to mold. In printing establishments handling multicolor or lithographic work, the control of the humidity is absolutely necessary if they are going to turn out high grade work and do so continuously. In some cases as much as two months elapse between the time the first color is put on the paper and the last color is applied, and unless the temperatures and humidity conditions are maintained constantly uniform, it is difficult to obtain uniform results from the color plates.

From a hygienic point of view, air conditioning may also be very valuable.

In the stemming rooms of tobacco plants dust is so thick that the girls generally have to work with sponges or handkerchiefs over their noses. The machines are so constructed that it is practically impossible to remove all the dust, but such elimination as is accomplished is done by furnishing humidified air to the room. In a plant making cotton or straw mattresses, air conditions were so bad that they never had a man who was able to work two months in winter without losing a few days each month. The health department made them put in an air conditioning plant and now the men work continuously and there is no loss of time by the men.

Among other things, the author exhibited jars containing a week's dirt from the air in a public school in Brooklyn, showing the great need of air purification in such establishments (34 pp., 28 figs. *d*).

## FRANKLIN INSTITUTE

*Journal, vol. 179, no. 3, March 1915, Philadelphia.*

Modern Views on the Constitution of the Atom, A. S. Eve.
Paints to Prevent Electrolysis in Concrete Structures, Henry A. Gardner (abstracted).

### PAINTS TO PREVENT ELECTROLYSIS IN CONCRETE STRUCTURES, Henry A. Gardner

The paper describes a series of tests made to determine what type of coating is best suited for the protection of metal imbedded in concrete against the action of electrolysis.

The paper fully describes the method of testing. The rods, previous to bedding, were thoroughly cleaned from scale and rust, then two coats of paint were applied, allowing a week's time for drying between the coats. Cement mortar was prepared from one part of Portland cement and two parts sand. In making up the specimens for tests, the author considered the objection to using paints which dried upon the metal to a glossed surface, thus preventing a proper bonding of the cement. To overcome this difficulty, he applied to the painted surface while it was still tacky (not dried), sharp particles of sand or similar material which, when allowed to drain upon a painted surface, became attached to the paint and dried with it, forming a rough surface resembling coarse sand paper. Emery powder abrasives and other substances were tested, but fine clean white sand was found to be the most useful.

In the test specimens where cracking has occurred the anodes showed considerable rust, the paint coating originally applied having been destroyed. On the cathodes in series I (painted iron rods, ½ in. in diameter and 12 in. in length, embedded in concrete cylinders, in upright position in mold, about an inch apart, and one inch from the bottom of the mold) the paint coatings were still intact, although some had apparently been affected by the moisture and the hydrated lime in the wet concrete, chalky surfaces being shown. Wherever there were small voids in the concrete, at or around the painted anodes, corrosion was most severe, and at such places pitting was evident.

The protective coating around the anode and cathode parts imbedded in the concrete cylinders which did not crack and which carried only a slight current, were found to be in a very good state of preservation. The breaking down of a film around the imbedded iron rods was always recorded by a sharp rise in amperage as well as by a fizzing sound, due to the increased evolution of hydrogen gas developed by the electrolysis of water in the damp concrete. This gas generally carried some water with it, forming small bubbles which burst with an audible explosion when a lighted match was placed in contact with them. The hydrogen gas seemed also to have a reducing or softening action upon some of the oxide bodies and carried to the surface of the cylinder considerable quantities of soft oily products which deposited around the anode and later hardened in contact with the air. Iron oxide was also carried to the top surfaces on some of the specimens by the action of the gas and water and was there deposited as a dark brown stain.

There can be no doubt that the nature of the paint films has considerable bearing upon the action of the hydrogen gas which was found to develop during the tests. Some paints gave good bonding tests but failed to act as insulators. Two lacquers composed of collodion and gutta-percha, respectively, dried to a flat surface, and gave a much better bonding than paints of a similar composition when dried to a glossed surface. Good bonding tests shown by several of the water paints are explainable through the wet concrete exercising a solvent action upon such paints, which gives opportunity for direct contact with the steel. Some paints which gave excellent results in the insulating tests gave conversely poor results in the bonding tests. Among these may be mentioned two paints composed of sandarac and shellac. Most of the oil pigment paints made with raw linseed oil gave poor or only fair results. It is probable that the raw linseed oil fails to dry hard, and although apparently well dried, remains in a semi-oxide condition so that the oil film is rather porous and therefore inefficient as insulation. Much better results were obtained with boiled linseed oil, a product which dries to a harder, less porous and more fully saturated film.

It is quite likely that the nature of the pigment used in a paint designed to prevent electrolysis of imbedded metal will have some bearing upon the results obtained from its use. Theoretically, pigments which are of a nonconducting nature should be preferable, such as inert pigments like asbestine, china clay and silica. There should also be present in a paint a sufficient quantity of rust-inhibitive pigment, (basic pigments or pigments of the chromate type), to produce a passive condition in the steel. The best results were given by protective compounds composed of processed and heat treated tung oil (Chinese wood oil) which dried to a hard nonporous film of a saturated nature. The author also recommends that the painted metal be "sanded" if possible.

The results of tests are reported in several tables. (24 pp., 14 figs. *eA*).

## INSTITUTION OF PETROLEUM TECHNOLOGISTS

*Journal, vol. 1, part 2, December 1914, London*

Initial Equipment and Organization as affecting the ultimate success of Oil Development Companies, John Wells.
Oils from Peat, Dr. F. Mollwo Perkin (abstracted).

### OILS FROM PEAT, Dr. F. Mollwo Perkin

The paper discusses the production of oils from peat and covers the chemistry of peat oil technology, work already done and commercial possibilities.

According to the statement of the author, there are many difficulties in the way of profitably extracting oil and other by-products from peat, but he does not believe that these difficulties are insurmountable. The initial difficulty and the one as a result of which most peat propositions have turned out failures, is to remove the large amount of water invariably held by the peat.

Here the question of economy of fuel must be taken into account. When peat is briquetted and dried so as to contain from 18 to 20 per cent of water, then on being charred, each ton produces from 5000 to 6000 cu. ft. of gas, having an average calorific value of 130 B.t.u. The process once started, the gas produced by carbonization is more than sufficient to continue the process and there is a certain amount of residual gas which can be employed for other purposes. But when the amount of moisture exceeds 20 per cent, the quantity of gas produced is not sufficient to carbonize completely the peat and extra fuel has to be employed.

On the plant of the Tarless Fuel Company, which is worked

under a considerable vacuum, peat may be carbonized satisfactorily and the by-products collected with a lower fuel consumption than when the distillation is carried out at atmospheric pressure.

How the water is to be eliminated in the first place is still an open problem. If the fibres are broken or disrupted, a much larger proportion of water can be forced out than from freshly dug peat, and a comparatively dry cake containing say from 30 to 35 per cent of moisture can be obtained. The peat can also be ground after it has been dug, without previous drying, the object of grinding being to break up the cells. Then the peat is briquetted and dried either by atmospheric exposure or by warm air. The author's experience is that peat briquettes should first be partially air dried before artificial heating is employed. Electrical processes have also been suggested for disintegrating the fibre. The labor item is a very serious element in all plans of making oil or carbon from peat.

The article contains a cost estimate for an experimental plant to produce 5 tons of dried peat per day for six months. (14 pp. *gp*).

### SCIENTIFIC SOCIETY OF THE ROYAL TECHNICAL COLLEGE, GLASGOW

CALCULATION OF CENTRIFUGAL STRESSES IN TURBINE ROTORS, Wm. Kerr

The paper discusses the calculation of centrifugal stresses in rotors, solid shaft, hollow shaft or drum type. As the original publication of the Society before which it was presented is not available, the abstract is made from a reprint of the paper in the *Mechanical Engineer*, vol. 35, No. 897, April 2, 1915, and April 9, 1915, page 257.

In a rotating body, two principal stresses have to be considered—the tangential or hoop stress $f_t$ and the radial stress $f_r$ (fig. 10). An elementary portion of the body being considered, the stresses acting on the surfaces of it must be in equilibrium with the centrifugal force of the element, this condition providing a relation between the stress and the velocity, while the consideration of strains gives other relations. These are written down in the terms of the radial displacement of the material at any radius, the value of this displacement being referred to as *expansion* and denoted by the symbol $u$. From the consideration of velocity and strains, a differential equation is obtained, which, when integrated, gives a general expression for $u$, containing two constants to be determined by the boundary conditions which exist in each particular case.

The equations will always be found to divide themselves into two parts; one deals with the effect due to the mass of the rotor body alone and the other with the effects of the external loads which it carries, such as the blading. This is of considerable value as it enables the designer to recognize whether excessive stresses are due to loading or form. The following notation and constants are used by the author: specific weight of steel = .283 lb. per cu. in.; Young's modulus for steel = 30 x $10^6$ lb. per sq. in.; Poisson's ratio for steel = 0.3; radial stress = $f_r$; tangential stress = $f_t$; expansion = $u$; external radius = $R$; ratio $\frac{R_o}{R} = a$; internal radius = $R_o$; ratio $\frac{r}{R} = b$; any radius = $r$; speed in r.p.m. = $N$; radial stress on external surface = $\rho$; total centrifugal force of rim and blades = $Q$; area of section of rim or drum = $A$.

*Solid Shaft Rotor.* The rotor body is composed of a solid shaft and the blading is fitted into grooves cut in the periphery. This means that a series of rings is formed on the surface of the shaft and in order to carry out the calculation, some assumption is necessary: either that the true radius of the shaft is the mean radius of the grooves, or the radius may be taken as that of the bottom of the grooves, in which case the collars are considered as an addition to the blade loading. The second method is perhaps the safer, as it leads to higher stress values. In the theory, consideration has to be given to a third principal stress; that is, the axial stress. Its equation is not given as it is of no practical importance,

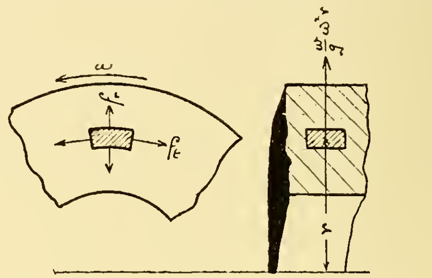


FIG. 10 CENTRIFUGAL STRESSES IN TURBINE ROTORS

but its influence on the radial and tangential stresses is considered in the determination of the expressions given for these. The general equations are:

For the radial stress at any radius $r$:

$$f_r = 3.46\frac{N^2R^2}{10^6}(1 - b^2) + \rho.$$

For the tangential stress at any radius $r$:

$$f_t = 3.46\frac{N^2R^2}{10^6}(1 - \frac{2}{3}b^2) + \rho.$$

Obviously, the maximum stresses are reached when $b = 0$ (that is, at the center of the shaft) and for these conditions, the radial and tangential stresses are equal, giving

$$f_r(\max) = f_t(\max) = 3.46\frac{N^2R^2}{10^6} + \rho.$$

The article discusses an example of this type of rotor and gives in graphical terms the results of complete investigation of the stresses occurring in it.

*Hollow Shaft Rotor.* The difference between this type and the solid shaft rotor is that the inner core of the shaft is removed, either for the purpose of cutting down the weight or to insure the soundness of the material subjected to the highest stresses. In the formulae following, the symbol $a$ represents the ratio of the inner radius to the outer radius, while $b$ has the same meaning as before. The general relations in this case are

$$\text{Radial stress} = f_r = 3.46\frac{N^2R^2}{10^6}\left\{1 - b^2 + a^2\left(1 - \frac{1}{b^2}\right)\right\} + \rho\left\{\frac{b^2 - a^2}{b^2(1 - a^2)}\right\}$$

$$\text{Tangential stress} = f_t = 3.4\frac{N^2R^2}{10^6}\left\{1 - \frac{2}{3}b^2 + a^2\left(1 + \frac{1}{b^2}\right)\right\} + \rho\left\{\frac{b^2 + a^2}{b^2(1 - a^2)}\right\}$$

In the equation of radial stress, the maximum value of the first term occurs at a value of $b$ different from that at which the second term reaches its highest value. Consequently, no exact expression of a simple nature can be given for the maximum radial stress. Since, however, the second term is usually of much less importance, the equation for the maximum might be made to suit the condition for the first term.

## SOCIETY OF AUTOMOBILE ENGINEERS

*Bulletin, vol. 7, no. 6, March 1915, New York*

Automobile Warning Signals, Alden L. McMurthy.
Eight-Cylinder Engine, D. McCall White (abstracted).
Automobile Horns.

The High-Speed, High Efficiency Eight Cylinder V-Type Engine, D. McCall White

The paper, after discussing in a general manner the eight-cylinder V-type automobile engine, compares it with either the four or six cylinder engines. In the matter of size, the eight (the author refers to the Cadillac Eight) is enclosed in practically the same hood space as was the four cylinder engine. The length is no greater but there is about a two-inch greater width. The weight is 50 to 60 lb. less than that of the previous four cylinder engine. From a mechanical standpoint, the V-type eight has the advantage of permitting the use of a short sturdy crankshaft, having only four throws.

As regards cooling, each block of cylinders is treated as a separate unit, although one radiator is common to both. There are, therefore, all the advantages of the four cylinder construction without its disadvantages. Beside, in the V-type eight, the amount of space to be cooled in each cylinder block is so small relatively that the variations in the temperatures of the forward and rear cylinders need scarcely to be taken into account. The temperature of cooling water is controlled by a thermostatic arrangement similar to that in an aneroid barometer. Forced lubrication is used, an oil pump of the gear type driven at one-half engine speed, being situated at the lowest point on the front cover of the engine, which makes it very accessible for examination. The wrist pins, cylinder walls and camshaft rockers are lubricated by the residue oil which is constantly coming out from the end of the bearings. As regards durability, the author believes that a well designed and properly made eight will considerably outlast an equally well designed and made six. His reason for this statement is that vibration more than use shortens the life of a motor: in the V-type eight, properly designed and manufactured, vibration is reduced to an almost negligible factor, and hence to the same extent longevity is increased. (20 pp., 1 fig., to be continued. *d*).

## WEST OF SCOTLAND IRON AND STEEL INSTITUTE

*Journal, vol. 22, nos. 4-5, January-February 1915, Glasgow.*

The Development of the Steam Turbine (discussion).
High Speed Steels, Fred. C. A. H. Lantsberry (abstracted).
"A Succinct Account of Huntsman's Cast Steel, 1792," Reprint.

High Speed Steels, Fred. C. A. H. Lantsberry

The paper discusses the subject of high speed steels and presents a very clear and interesting historical and general review of the subject.

Among other things, the author describes an investigation made by him at the works of the Birmingham Small Arms Company with a view to determining the most suitable steel for the manufacture of milled twist drills. The properties required for a twist drill are more exacting than those required in a turning tool, in addition to which, in the turning tool the principal factor is undoubtedly hardness while in a drill mechanical strength and toughness are at least of equal, if not of greater importance. It appeared, therefore, necessary to test steels in a way adapted to this particular purpose.

Consequently, a special drilling machine was designed for the test, making it possible to obtain feeds of from 0.010 to 0.0675 in. per revolution and speeds of from 100 to 400 r.p.m. A standard drill size of $^{15}/_{16}$ in. diameter was adopted for the test, as being a size which is very largely used in English machine shop practice. A standard speed of 400 r.p.m. and a feed of 0.019 in. per revolution were adopted for the test in which the drills were lubricated, but in order to give some idea of the red-hardness of the various steels, tests were made in which the drills were run dry. For these tests, the same feed was maintained but the speed was reduced to 305 r.p.m. The number of inches of steel drilled was then taken as a measure of the suitability of that particular high speed steel for the purpose of drill making. In every case the drill was run until it absolutely refused to cut any more steel, when the point of the drill was quite worn away or the drill had broken.

A large number of proprietary steels were tested in this way but none of them were found to be particularly suitable for drill making. Special experiments were therefore made on the influence of tungsten, chromium and vanadium and the drilling properties of high speed steels, with carbon content as nearly as possible at 0.6 per cent. The first series of steels contained also constant chromium content, while the tungsten was increased from 10 per cent to 25 per cent. It was found that the efficiency of the steels as drills increased to a maximum and then fell as the tungsten passed 14 per cent. This figure was taken as the most desirable tungsten content, and upon this basis, another series of steels was obtained in which the chromium was increased from 1.5 to 7.5 per cent, the efficiency of the steel reaching a maximum and then falling off again as the chromium increased. It was found that the effect of molybdenum was slight and not sufficiently promising to warrant its use.

Altogether it was found that a really excellent high-speed steel is that containing 14 per cent tungsten and 4 per cent chromium, although the author does not claim that this is the best combination possible. Drills of the composition finally arrived at were deemed poor if they failed to penetrate 100 in. of the test steel. Further, the new steel would cut at a penetration of 25 in. per minute, while the ordinary steel would not cut at a greater penetration than 12 in. per minute.

In the discussion which followed, in answer to a question as to whether an addition of say 1 per cent of vanadium above the quantity eliminated in manufacture would be of any use, the author told of tests of a special steel containing 1 per cent of vanadium; drills made from it were of absolutely no use. It appears, therefore, that the only valuable effect of vanadium is that which it has during the process of making the steel. (24 pp., 8 figs. *hge*).

## MEETINGS

### CHICAGO, MARCH 19

A meeting of unusual interest was held by the Chicago local section on March 19, devoted to the subject of Refrigeration with special reference to Ice-Making as a By-Product of Central Stations. The meeting which was held in the ball room of the Hotel La Salle, was addressed by Heywood Cochrane, western manager of the Carbondale Machine Company, Chicago, who outlined the principal refrigerating methods in which ammonia is used as the refrigerant, then discussed the economies of usual ice-making practices with reference to the supplies of power, distilled water and steam, and finally explained the advantages of suitable combinations of such plants with power plants having excess exhaust steam available, with which important savings can be effected. Mr. Cochrane referred particularly to absorption machines and discussed a number of forms of installations of such apparatus in connection with steam plants, showing results and test data. He stated that in the case of a lighting plant with low revenue from the sale of current, the installation of a properly designed refrigerating auxiliary will prove more profitable than the original lighting plant, and in the case of a combined water and lighting plant, the addition of refrigerating equipment is even more advantageous. Mr. Cochrane's paper drew out a large amount of discussion, interesting addresses being presented by Otto Luhr and John M. Westerlin, both consulting refrigerating engineers of Chicago and by Fred Wittenmeier, vice-president and chief engineer of Kroeschell Bros. Ice Machine Co. of Chicago. A more complete account of the meeting will appear in an early issue of The Journal.

### BUFFALO, MARCH 25

At a meeting of the Buffalo Engineering Society on March 25, an address on Our Navy and What it Means was delivered by Edward Breck, Field Secretary of the Navy League of Washington, D. C. Dr. Breck illustrated his address with a number of stereopticon slides, showing the progress of the American Navy up to the present time. He presented in addition some very interesting statistics regarding the growth of the navies of the world, as well as historical data which proved conclusively that preparedness is the best and only way to avoid war.

About 200 members were present at the meeting.

### BOSTON, MARCH 31

At a local meeting in Boston on March 31, Harry Gay, equipment engineer in charge of the work for Stone & Webster Engineering Corporation, gave an illustrated talk on the Engineering Equipment of the New Technology Buildings; Geo. E. Libbey, of the firm of Hollis French & Allen Hubbard, presented the Heating, Ventilating and Sanitary Features of the Work; and A. L. Williston, President of Wentworth Institute, gave an illustrated talk on the Lay-out of Educational Institutions.

### ST. LOUIS, APRIL 7

At a joint meeting of the St. Louis Engineering Societies on April 7, Edward E. Wall gave an extremely interesting paper on the City Water Supply. He spoke first of the steps necessary to bring to the highest efficiency the present water supply, which averages 120,000,000 gallons a day, with a maximum capacity of double that amount. The speaker advocated a new covered storage basin at Baden, additional pumps and pipe line, and the rebuilding, enlarging and covering of the Compton Heights Reservoir.

The requirements of ten years from now were next discussed. At that time, it is believed, the city's water requirements will be double the present amount. This increased supply can be obtained either from the Mississippi River by substantially duplicating the present plant, or from the Missouri River. The estimated cost of the two schemes is about the same, and since the Missouri supply presented a number of advantages, the author favored working along this line.

### BUFFALO, APRIL 8

On April 8, the Buffalo Engineering Society accepted the invitation extended by the Federal Telephone and Telegraph Company and inspected the new automatic telephone system installed in their Buffalo plant. Mr. Hershey of Chicago presented a detailed explanation of the construction and operation of the automatic telephone apparatus and illustrated his talk with stereopticon slides. After the lecture a thorough inspection trip was made through the plant and the apparatus was shown and explained under operating conditions.

### PHILADELPHIA, APRIL 12

A joint meeting with the Philadelphia Section of The American Institute of Electrical Engineers was held on April 12. J. S. Barstow read a paper on Turbine Driven vs. Engine Driven Units in Small Capacities. Mr. Barstow showed a number of slides illustrating the various apparatus mentioned. The paper was followed by a general discussion.

### NEW YORK, APRIL 13

The monthly meeting of the Society in New York for April was devoted to the subject of elevators, with particular reference to the traction type of elevator machine used in the tall buildings. On account of the importance of this question in New York City, the paper attracted an unusually large audience, approximately 480 being in attendance. The meeting was addressed by David Linquist, chief engineer of Otis Elevator Company of New York, the subject of his paper being: Modern Electric Elevator and Elevator Problems. He took up first, the traction electric elevator, giving comparisons of the gearless traction type with the geared traction type, second, installations with details of their performance in service, efficiency, power consumption, acceleration and retardation, and third, the application of ball and roller bearings to elevator machinery. The address was profusely illustrated by lantern slides and drew out considerable discussion. A more complete account of the meeting will appear in an early issue of The Journal.

### SAN FRANCISCO, APRIL 16

The San Francisco Section of The American Society of Mechanical Engineers held its spring meeting on April 16. The paper of the evening was read by G. C. Noble on the

Design and Test of a Large Reclamation Pumping Plant. The plant in question is that built for Reclamation District No. 1500, otherwise known as the Sutter Basin project, situated in the Sacramento valley near the confluence of the Sacramento and Feather rivers. This plant is probably the largest centrifugal pumping plant in the United States if not in the world, having a total capacity of 676,000,000 gal. of water per day, and requiring 5000 h.p. for its operation. Six 50-in. diameter pumps, operating against a maximum head of 29 ft. at a speed of 248 r.p.m., are direct-connected by means of flexible leather link couplings to constant speed motors. Duplex motor-driven vacuum pumps are employed for priming purposes and the plant equipment includes in addition the usual accessories. Mr. Noble's paper was illustrated by lantern slides. The entire subject is one of peculiar interest to Pacific Coast engineers.

## NECROLOGY

### JACOB ROBINSON ANDREWS

Jacob Robinson Andrews was born September 6, 1861, at Bridgewater, Mass., and was educated at Bridgewater High School and Bridgewater Academy. In 1879, he obtained employment as apprentice in the machine shop of the Hyde Foundry at Bath, Me. He was rapidly advanced to the position of foreman, and a few years later was made vice-president and general manager of the Hyde Windlass Company. When this firm separated from the United States Shipbuilding Company in 1905, he became president.

Mr. Andrews worked untiringly to advance the interests of American shipping and was one of the best known figures in shipping circles. He was a member of the Society of Naval Architects and Marine Engineers and the Engineers Club of New York. He died in New York City on March 25, 1915.

### JAMES FINNEY MCELROY

James Finney McElroy was born in Greenfield, Ohio, on November 25, 1852. He attended the Salem Academy at South Salem, Ohio, in 1869 and the Bloomingburg Academy at Bloomingburg, Ohio, from 1870-1872. He was graduated from Dartmouth College in 1876 with the degree of A.B. and received the degree of A.M. from there in 1879. From 1876-1880, Mr. McElroy was principal teacher of the Indiana Institute for the Blind at Indianapolis and from 1880-1887 he was superintendent of the Michigan Institution for the Blind, at Lansing, Mich. For this institution, he designed and constructed the heating and power plant.

In 1887, he organized the McElroy Car Heating Company at Buffalo which operated under its own patents. In 1889, this concern was combined with the Sewell Car Heating Company forming the Consolidated Car Heating Company in Albany of which Mr. McElroy was consulting engineer and acting president to the time of his death. He died on February 10, 1915.

### WILLIAM MCINTOSH

William McIntosh was born August 20, 1849, and had a common school education. From 1867 to 1870 he served an apprenticeship with the Chicago, Milwaukee and St. Paul Railway. He was employed by the Chicago and North Western Railway for 27 years, in the capacity of foreman at Waseca, Minn., and Huron, S. Dak., and of master mechanic at Winona, Minn. He left this position to become superintendent of motive power with the Central Railroad of New Jersey. When in 1909 he resigned on account of ill health, he claimed forty years of active railroad service. He died on March 16, 1915.

Mr. McIntosh was a member of the New York Railroad Club, the Canadian Society and the Engineers Club.

## PERSONALS

Arthur W. de Revere has been appointed district sales manager of The Terry Steam Turbine Company, with offices in Chicago, Ill.

Daniel M. Luehrs has severed his connection with the American Blower Company, Detroit, Mich., as engineer in charge of the air washer department, and is now general superintendent of the Guilford Avenue Plant of the Crown Cork and Seal Company of Baltimore, Md.

M. C. Stuart, formerly assistant steam engineer at the Cambria Steel Company, Johnstown, Pa., has been appointed a mechanical engineer at the U. S. Naval Engineering Experiment Station, Annapolis, Md.

Claude A. Bulkeley has accepted the position of chief consulting engineer with the Canadian Domestic Engineering Company, Ltd., Montreal, Que., Canada. Until recently Mr. Bulkeley practiced consulting mechanical and electrical engineering in New York City.

Walter N. Cargill has been appointed superintendent of power and lines for the Rhode Island Company, Providence, R. I. He was until recently associated with the Stone & Webster Engineering Corporation of Boston.

Thomas H. Belcher has resigned his position with the Black-Clawson Company, Hamilton, O., and has accepted the position of manager of the Carthage Machine Works, Carthage, N. Y.

Homer S. Burns has accepted a position with the Freeport Sulphur Company, Freeport, Tex., as mechanical engineer. He was until recently in the employ of Westinghouse, Church, Kerr & Company, New York, as superintendent.

Clarence Boyle, Jr., formerly district sales manager of the Taylor-Wharton Iron and Steel Company, Scranton, Pa., has become associated with Clarence Boyle, Inc., Chicago, Ill.

Reginald J. S. Pigott is severing his connection with the Interborough Rapid Transit Company, New York, as mechanical construction engineer, to take up the position of power engineer for the Remington Arms-Union Metallic Cartridge Company at Bridgeport, Conn.

## STUDENT BRANCHES

*Members of student branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate delivery of The Journal.*

### ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting of the Student Branch of Armour Institute of Technology on April 8, F. G. Gasche, chief mechanical engineer of the Illinois Steel Company, gave an illustrated talk on The Evolution of the Modern Steam Engine and Power Plant Transmission as Developed in the Steel Industry. Mr. Gasche told of the rapid development of the steam engine for blower purposes and showed how fast the D-slide valve and the Zeuner diagram were going out of use. The methods used in making I-beams, channels and steel rails were clearly demonstrated by the pictures shown.

### CARNEGIE INSTITUTE OF TECHNOLOGY

The regular meeting of the Carnegie Institute of Technology Student Branch was held on March 10. Mr. Chester of Babcock & Wilcox Boiler Company read a paper on Modern Boiler Practice. He spoke first about the new A.S.M.E. Boiler Code, and told of many of the variations in boiler practice which it was designed to eliminate. In discussing boiler plants, he said that the large unit was desirable, but that it was usually broken up into a number of smaller units so that one or more could be held in reserve. Much progress is being made in combined boilers, superheaters, and economizers. Superheaters first became common in the United States in 1900, and at present about one fourth of the total boilers are equipped with them. Stacks are being replaced by mechanical draft, and more attention is being paid to the brickwork, so as to stop leaks, etc.; higher temperatures can be obtained than the fire brick will stand, and it has been found difficult to hold up the arches. By means of slides Mr. Chester illustrated many of the different types of boilers, settings, and stokers.

The meeting of the Branch, held on April 14, was one long to be remembered by the members, inasmuch as they were addressed by Dr. John A. Brashear, President of the American Society of Mechanical Engineers.

Professor W. Trinks first spoke to the graduate members briefly, explaining to them the advantages to be derived by becoming members of the A.S.M.E., and urging them to join the organization.

Dr. Brashear was then introduced and gave an interesting talk on Engineering as Applied to the Construction of Telescopes. He said, we need the civil engineer for location, the mechanical engineer for construction, the electrical engineer for control, and so on down the list of the various branches of engineering. His talk was illustrated by lantern slides. With the aid of these, he described astronomical instruments from their early crude forms to their present highly developed forms and showed the famous collection of Chinese instruments on the walls of Pekin, many of which had been taken by the various nations concerned in the Boxer Rebellion. He stated that every nation but Germany had returned these, and that he expected Germany to do likewise. For more than four thousand years the Chinese kept records upon which astronomers have placed great dependence. He showed and described many different types of telescopes, among them being those of Lord Ross and Sir Howard Grubb, the great forty-eight inch of Herschel, the twenty-six inch reflector at Lick Observatory, and the Snow Telescope at the same place.

Dr. Brashear dwelt for some time on the mechanical and electrical details of the telescope. It is no longer a difficult task to make observations with a large telescope. The observer merely sits in a chair and by simply touching buttons or moving levers, he can make these great masses take any position, hairline adjustments being easily made. If the telescope rises above the observer's eyes he can raise the floor to any desired level.

He showed the telescopic photographic apparatus, which he said had done so much for astronomy. The retina of the eye becomes tired very quickly, and hence visual observations are limited. The photographic plate, however, can be exposed to the action of heavenly bodies for many hours and thus receive impressions that otherwise could not be detected. In this connection, he spoke of the delicate gearing required for keeping the telescopes on the stars automatically and said that in the most carefully cut gears errors as great as one sixteenth of an inch appeared. This had to be eliminated by careful grinding.

He then showed views of his own shops, where much work in the construction of astronomical instruments has been done and is being done. Among these was that of a six-foot diameter mirror that was in the course of preparation. He told of the great accuracy and delicacy with which the various gratings, mirrors, and prisms had to be handled, laying great stress upon the effect of variations in temperature in the vicinity of these bodies. It is possible to measure to one millionth of an inch and to detect errors to one five millionth of an inch. He said that we must remember any machine that does the work for which it was designed is accurate enough.

Dr. Brashear explained why the mirrors used in astronomical work were of such great thickness, saying that the least flexure was obtained when the thickness was one sixth of the diameter. These large and valuable objects are shipped in loose packing in a box and this box is then packed in another box. This method has proved entirely satisfactory. He also described a simple method used in obtaining a plane surface. This is done by matching three surfaces, and using sodium light as a detector. Prof. W. Trinks, Mr. Estep and Mr. Williams took part in the discussion which followed.

### CORNELL UNIVERSITY

The Cornell University Student Branch held a public meeting on March 10, at which Prof. H. S. Jacoby of the College of Civil Engineering addressed the members and their friends on the Maximum Spans for Different Types of Bridges. Supplementing his descriptions with lantern slides, he discussed the principal types of such structures from the simple plate-girder to the new Manhattan suspension bridge.

### COLORADO AGRICULTURAL COLLEGE

At a meeting of the Colorado Agricultural College Student Branch on March 10, H. A. England gave a detailed and instructive talk on Mining Machinery. This included drills, drilling machinery, and methods of drilling holes and removing material. He spoke also of air compressors and pumps as used in mining.

Mr. Edmonson then gave an account of his visit to the plant of the Commonwealth Edison Company in Chicago. He discussed the coal and water supplies and the railroad facilities, and emphasized the immense size of the boiler plants.

### LELAND STANFORD UNIVERSITY

At the regular meeting of the Stanford Branch of the American Society of Mechanical Engineers on March 23 C. J. Coberly gave a highly interesting and instructive talk on the history of Colored Photography and on his experiences in that line of work. He illustrated his talk with samples of his work.

J. A. Shepard spoke on his experience in hydro-electric work in Colorado, and the difficulties to be overcome in power plant operation.

### MASSACHUSETTS INSTITUTE OF TECHNOLOGY

At a meeting of the Mechanical Engineering Society of the Massachusetts Institute of Technology on March 24, F. L. Fairbanks of the Quincy Market Cold Storage Company gave an illustrated lecture on The Design and Construction of a 1000-ton Ammonia Compressor. The possibility of making a larger machine of this nature without any assembly or even assembly drawing was discussed at length by Mr. Fairbanks, for it was in this way that he designed and erected the 1000-ton machine, which is the largest of its kind in the world.

### OHIO STATE UNIVERSITY

At a meeting of the Ohio State University Branch on March 19, the following officers were elected for the ensuing year: H. Burnham, chairman; W. M. Leonard, vice-chairman; S. J. Cobb, secretary; M. A. Nettleton, treasurer; A. F. Landefeld, sergeant-at-arms. P. W. Sheatsley, secretary of the branch, gave a short talk on The Generating Plants of the Commonwealth Edison Company of Chicago.

### PENNSYLVANIA STATE COLLEGE

The Annual Mechanical Banquet, given by the Juniors of the Pennsylvania State College Student Branch to the Seniors, was held on March 18. The toastmaster was V. D. Longo, '16, vice-president of the branch. The following toasts were given: Strength in Union by J. A. Mease, pro-

fessor of machine design; Our College by H. Diemer; New Methods by J. P. Calderwood, professor of mechanical engineering; Good Fellowship by E. D. Walker, dean of the School of Engineering; Locomotion by A. J. Wood, professor of railway mechanical engineering; Association by E. N. Bates, professor of mechanical engineering; State Students by O. F. Bourke, professor of economics; Engineers of 1915 by W. D. Garman, '15, president of the branch; and Engineers of 1916 by G. Jeffery, '16.

### PURDUE UNIVERSITY

Charles J. Peck, M. E., '06, gave a very interesting talk on Valves and Other Fittings Used in Modern Piping, before the Purdue Branch of the A.S.M.E. on March 16.

Mr. Peck outlined very clearly the method of finding any required fitting in the catalogue issued by his company in which 16,500 articles for use in piping work are listed. All fittings are marked with the highest pressures they are designed to stand, and it is the duty of every engineer to see that the pressures are not exceeded.

To withstand these pressures many different materials are needed. Sometimes cast steel is used; sometimes malleable iron or cast iron will suffice. In all fittings where brass and nickel are used special grades of these materials must be provided to suit the different conditions. Hydraulic pressures as high as 5,000 lb. per sq. in. and temperatures of superheated steam upward of 750 deg. fahr. are often met with.

Mr. Peck next explained the fittings in detail. The most widely used piping formerly was wrought iron, but the modern steel piping has largely superseded it. Most piping now is of the flanged type and several examples were shown by the speaker. Section of gate and globe valves were shown; the former is more expensive and is used on water lines and on large steam lines; the latter is cheaper and is much used for smaller lines. The automatic stop valve for boiler work is a great help in power plant work, as it will cut in or out a boiler as the pressure reaches or drops below the line pressure.

The last branch Mr. Peck described was the modern tilting trap and the drainage and direct return types. The former is very simple, and operates to drain a line of condensed steam without the loss of live steam. The direct return type will force the condensed steam back into the boiler and is a much more efficient means than the ordinary duplex pump when pure water is used. The tilting trap can be used on anything from a heating plant to a modern power plant.

A meeting of the branch was held on March 31. The society was addressed by Frank Rasmussen of the Link-Belt Company of Chicago, who gave an illustrated lecture on The Elevating and Conveying of Materials.

Mr. Rasmussen is a graduate of the mechanical department of the State College of Colorado, and received his degree in 1901. His position with the Link-Belt Company has given him the opportunity to design conveyors for many new and difficult installations, and to investigate many other varied types of elevating machinery. He presented a number of lantern slides illustrative of the conditions commonly met with and of the types of conveyors installed.

Chain is the basis of nearly all conveyors. The common kinds are built up of detachable links, that breakages may be replaced. This detachable chain was developed originally for harvesting machinery to give a flexible as well as positive drive, but its worth has been so well proven that thousands of feet are made annually for all sorts of purposes.

Confining his talk to conveyors and elevators, Mr. Rasmussen illustrated many types of chains: Roller chains provided with hooks for car haulage in mines; flight conveyors, which scrape the material along in a trough to the desired location; the chain driven combination elevator and conveyor bucket, used especially for coal in power plants like that at Purdue; the overlapping platform conveyor for heavy materials at low speeds, like mine "picking," and the continuous bucket type for similar elevation.

Other types of conveyors for special purposes are the rope conveyors often used in bakeries in connection with spiral chutes. In this connection Mr. Rasmussen mentioned that a conveyor is being developed to run through an oven, that the baking may take place while the bread or cake is in motion, and may be a continuous process. The remaining conveyor which is used at all is the flat belt type, this being one of great capacity at all speeds. The last few illustrations outlined thoroughly the process of washing and drying coal in the modern mine.

L. D. Rowell, of the electrical department, gave a very interesting lecture on The Modern Battleship before the Purdue University Student Branch in the Mechanical building on April 13. He gave a detailed outline from the beginning of the iron clad vessel to the present time, comparing the ships of the United States with those of the other world powers.

The average American layman knows little about the United States navy in reference to its present condition or its development. He is oftentimes influenced by the more rabid newspapers into believing that the navy is useless and that the American ship yards know little about the construction of the modern warship.

Prof. Rowell proved conclusively that this statement was false. He started with the time of the Monitor and Merrimac. This battle was without a doubt one of the most unique naval conflicts ever fought, not because of the number of men killed or the decisiveness of the victory, but because it marked a new era in warfare. It marked the end of one type of vessel and the beginning of another.

Captain John Ericeson was the hero of the first battle of the Iron Clad. His name has gone down in history as one of America's greatest engineers.

Prof. Rowell compared very minutely the destructiveness and accuracy of the shells fired from the Iron Clad with those of the present day vessel. One broadside fired from a modern warship will do as much damage at six miles as a continuous fire from the Merrimac did in over four hours at point blank range.

The American Navy degenerated after the Civil War. It became the laughing stock of the world. It took twenty years to build some ships. The year of 1884 marked the beginning of the second era. Important steps were taken about this time to perfect the navy. The armored turreted battleship was introduced and the armored cruiser constructed. Among other types of vessels that have since been built are the hospital ship, the collier, the torpedo boat, the submarine, the destroyer and the dreadnought. Prof Rowell discussed these, explaining in detail the action of the guns of each type, their destructiveness, accuracy and speed.

The speaker stated that although the navy of the United States according to size, was not the strongest nevertheless it surpassed the navy of any other country in every other respect.

### STEVENS INSTITUTE OF TECHNOLOGY

On March 9, James Hartness, president of the Jones & Lamson Machine Company, and past president of the Society, gave a lecture on Machine Tool Design before the Stevens Institute of Technology Student Branch.

On March 10, the Stevens Engineering Society conducted a party of students to inspect the plant of the Astoria Gas Light and Power Company, and another party on March 17 to see the process of manufacture of prepared soups at the plant of the Franco-American Soup Company in Jersey City. The last inspection trip of the year was made on March 24 to Jacob Ruppert's Brewery, New York.

### UNIVERSITY OF CALIFORNIA

At a meeting of the University of California Student Branch on March 2, Eugene Arnot gave a talk on the Construction and Care of Exide Storage Batteries. Walter Allat spoke on the Construction of the Edison Storage Cell, and described tests which had been performed upon it.

At a meeting of the branch on March 30, John W. Dinsmore read a paper on Gun Powder Used in Big Guns, deal-

ing also with methods of projectile velocity measurement. The paper was discussed by A. C. Moorhead, H. L. McLean and Mr. Kennedy.

### UNIVERSITY OF COLORADO

At a meeting of the University of Colorado Student Branch on March 25, the following officers were elected: Edison B. Good, president; Barrett Morrison, vice-president; C. Roy Goodner, secretary-treasurer.

Mr. Bagnall, salesman for the American Radiator Company in Denver, Colo., gave a brief history of Heating and Ventilation from the ancient Egyptians down to the present time. He said that the air valve for steam radiators as well as many others means of heating and appliances for steam radiators were the inventions of Colorado men, for instance the blast heating system. The United States leads in methods of ventilation, although some few ideas have come from England and Germany. The speaker suggested that radiators on account of their unsightliness be placed within base-boards, window-frames or door-frames. Typical problems of heating were given, showing the relation of the heat required to radiators, size of boilers, size and height of chimney and size of pipes. The various types and styles of steel and cast-iron boilers, valves, thermostats and temperature regulators were also discussed.

### UNIVERSITY OF ILLINOIS

At a meeting of the student branch of the University of Illinois on February 26, the four-reel film, From Molten Steel to Automobile, issued by the Maxwell Company, was presented. This showed all the details in the construction of a modern gasoline car. Beginning with crude steel, the processes of casting and forging were shown in their entirety. After this, came the making of the various other parts such as the chassis and the minor engine parts.

At a meeting on March 12, H. T. Scovill of the accountancy department of the same company gave an address on Opportunities for Mechanical Engineers in Cost Accounting. In his opinion cost accounting and efficiency engineering offer a broad field for the technically trained engineer who is keenly observant and possesses the ability to handle men. The efficiency engineer reduces the cost of production by half. At the Ford factories men working at benches were spending four of their nine hours a day in walking, and the efficiency engineer was the man who saved steps. The man who can save time and money in production will benefit consumer and producer alike.

### UNIVERSITY OF KENTUCKY

A special meeting of the University of Kentucky Student Branch was held on February 24, at which Calvin W. Rice, Secretary of the Society, gave a very interesting talk. He spoke first about the plans of the Society in forwarding the work among the student branches. The latter part of his talk was devoted to an account of the trip to Germany in 1913, and was illustrated with lantern slides. Among the most interesting views were those showing the German Museum in Munich which contains a working model of possibly every piece of machinery ever made. Each model is constructed so that the actual operation of the machine may be seen. An extraordinary feature of this museum is that no money has been donated by the government toward the collection of these models.

### UNIVERSITY OF MAINE

At the last meeting of the University of Maine Student Branch, G. G. Holbrook of the Bath Iron Works delivered a very interesting and instructive lecture on Cost Estimates of Engineering. He divided his subject into the following topics: material, labor, overhead, margin, profit and delivery. The various methods of working out the cost of these several items were discussed by the speaker.

### UNIVERSITY OF MICHIGAN

The University of Michigan Student Branch held a regular meeting on April 2 at which Prof. John R. Allen, dean of the Robert Engineering College of Constantinople, gave a very interesting lecture on Engineering in Turkey. The speaker first discussed the character and traits of the Turkish people, and then discussed the City of Constantinople, illustrating his talk with lantern slides. He told of the commercial facilities of the famous old city due to its excellent location. Constantinople has sixty-five miles of water front; the fronting on the Bosphorus being especially valuable as the Bosphorus is deep right close to the shores.

### UNIVERSITY OF MINNESOTA

On March 3, an open lecture under the auspices of the Minnesota Student Branch was given by a representative of the Carborundum Company to the whole Engineering College. The lecture was illustrated with lantern slides, and showed in great detail the manufacture of the carborundum itself and that of the various types and sizes of grinding wheels used.

On March 11, the branch held a meeting at which Prof. W. T. Ryan, of the department of electrical engineering, spoke on Diversity Factors in Central Station Operation. The diversity factor shows the ratio between the power actually used by a consumer and that which the apparatus installed for him can give if called upon. The factor has been investigated for a number of cities, and Professor Ryan has carried out such an investigation for the principal cities and towns of Minnesota. The lecture was exceedingly interesting and practical.

On March 18, under the auspices of the branch a reel of Ford films was shown to the Engineering College. Prof. S. C. Shipley of the mechanical engineering department, who visited the plant last summer, gave an explanation of the film. The lecture showed the famous assembling conveyor which makes the "1000 cars a day" possible. It also showed the complete assembling of a car from the point where the frame is placed on the conveyor to that where the car runs out of the shop under its own power. The audience filled the Engineering Auditorium to capacity.

### UNIVERSITY OF MISSOURI

At a meeting of the University of Missouri Student Branch on March 25, W. A. Sloss gave a talk on The Oil Industry. He described the methods employed in prospecting for oil, opening new wells and installing machinery, and explained the work in detail up to the delivery of the crude oil at the refinery.

### WORCESTER POLYTECHNIC INSTITUTE

By invitation of the Alumni and the local members of The American Society of Mechanical Engineers, the Worcester Polytechnic Student Branch were present on April 8, at the organization of the Worcester Section, Am. Soc. M. E. Ex-Mayor James Logan, Manager of the United States Envelope Company, presided. He spoke briefly of the need of an organization to bring together the varied engineering interests of the locality; and then called upon Dr. Ira N. Hollis, President of the Worcester Polytechnic Institute, who called attention to the help which this section could give to the engineering college of which he is the head and especially to the Student Branch.

Calvin W. Rice, Secretary of the Society, was introduced and spoke of the value of the various local sections of the Society, placing particular emphasis upon the growing interests of the professional engineer in civic affairs.

An interesting address on the Submarine was given by R. H. M. Robinson, formerly Naval Constructor, and now general manager of the Lake Torpedo Boat Company. The speaker began with a historical sketch of the submarine, the first successful one being that of David Bushnell, in 1773, followed by Robert Fulton's submarines. He then gave a brief description of the various submarines being built in the United States, Germany, France and Italy, and supplemented his description with lantern slides showing the five types of submarines. These are the Holland and the Lake, which are built in the United States; the Lebeif, the French boat; the Krupp-Decevilley, Germany's type of boat; and

the Fiat-Laureti, which is of Italian design. There is practically no protection for a battleship against a submarine. The battleship of the newest type represents an expenditure of about $16,000,000 and this great fighting machine can be put out of commission, if not sunk, by a single torpedo from a submarine. The United States is building submarines which will have a cruising radius of from 4000 to 5000 miles. The German submarines have been working in a radius of from 1100 to 1200 miles and this is considered remarkable. While it is not probable that the present submarine is all that is necessary in naval warfare, it is a beginning of a new style of naval armament. For motive power, submarines depend upon storage batteries and combustion engines, but it is likely that steam driven submarines will soon be built. There have been steam submarines, but with poorly developed engines and boilers, they were found impracticable. With the newer developments in steam engines and high pressure boilers, however, the steam type will be a success.

Commodore Robinson said he believed that the German submarines were using a short range torpedo with an extremely heavy charge for operating against war ships, but with an extremely light charge when attacking merchant vessels. He called the Whitehead torpedo the best developed mechanism in the world and told of the exhaustive tests given each torpedo before sending it out to be used.

## EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

### POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer.*

*In sending applications stamps should be enclosed for forwarding.*

059 Mechanical engineer and chief draftsman in the engineering department of large industrial concern. Prefer man who has had several years experience in design and application of coal and ore handling apparatus, ore and slag crushers and blast furnaces; steel, brick and wood buildings, bridge work and general steam and power plant engineering. Name confidential, apply by letter.

088 Assistant works manager for firm manufacturing cranes and electrical specialties; A-1 man with engineering experience in structural, mechanical and electrical work, and previous work in connection with modern manufacturing methods. Location Michigan. Apply through Society.

093 Experienced mechanical draftsman, capable of doing some designing; one preferred with experience in machine tool and shop practice and with a fair technical knowledge. Location Connecticut.

099 Professor of mechanical engineering for Southern University. Apply by letter.

0101 A large manufacturing concern wishes to engage as employment head, a man of special ability in the selection of labor, to be permanently located at the factory. Should be able to select men of proper character, who would have the training for the different classes of work carried on in the various departments. Apply by letter stating age, experience in full, and salary wanted. Location Philadelphia. Name confidential.

### MEN AVAILABLE

*The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period.*

E-72 Junior, M.E. graduate Lehigh University, several years experience as draftsman, chief engineer's assistant, foreman and manager, at present located in prominent technical institution in New York, desires summer position which would afford experience in the mechanical field. Salary and location immaterial.

E-73 Junior member, age 26, Brown Univeristy graduate with experience in the design and inspection of power plant construction, desires position where experience in testing and operation can be obtained.

E-74 Member, age 34, technical education, married, with broad experience with leading engineers in the East on the design of steam power plants, heating and fire protection systems and inspection of mill and power plant construction and equipment, desires position with large manufacturing or engineering concern; at present employed as superintendent of construction on large mill and power plant.

E-75 Member with wide experience in the design of all manufactures of engines and power plant work, desires position with company engaged in gas or steam engineering; would also consider offer with a consulting engineer.

E-76 Member, graduate mechanical engineer, 20 years experience as designer and chief draftsman with leading manufacturers of simplex and duplex steam pumps, desires position.

E-77 Graduate M.E., age 39, 15 years consecutive and successful experience from shop apprentice to agency manager; with one large corporation nine years, manufacturing steam and producing gas engines, producer transmission and special machinery; has held positions as draftsman, designer, estimator, sales engineer, mechanical engineer and agency manager; also experienced in efficiency engineering. At present employed but desires change.

E-78 Associate-member, Stevens graduate, age 27, has had practical experience in all departments of gas engine manufacture, designing, machine work, assembling, testing and sales work, desires position as assistant to factory manager or to superintendent. Will begin at salary of $1500. At present employed.

E-79 Stevens graduate, 1883, with experience as superintendent of bridges and buildings, and one who has specialized in railroad shop design, construction and equipment, desires position.

E-80 Member, sales engineer, thoroughly familiar with business methods and present conditions of Scandinavian countries and Russia, desires to represent firms manufacturing machine tools, power and transmission machinery, small tools and general supplies.

E-81 Member, graduate Massachusetts Institute of Technology, 1901, age 35, married, desires position about May 1st as works manager or general superintendent of large manufacturing plant; experience as such covers about 12 years. Familiar with up-to-date methods of shop management. Has successfully handled from 1000 to 1500 men.

E-82 Member, technical graduate, age 36, mechanical and electrical engineer thoroughly practical, original and efficient, 13 years experience in responsible capacity, designing, manufacturing and selling water turbines, governors, penstocks and accessories for hydro-electric installations; also experienced in making preliminary surveys, reports, efficiency tests and investigations of power propositions, writing specifications and purchasing material, desires position where these qualifications, coupled with executive ability are desirable. With present employer 12 years. Location preferably East or South.

E-83 Associate-member, age 42, experienced in superintending masonry, concrete, brick and steel construction, also installation and maintenance of mill machinery, drafting, foundry, forge, pattern, machine and bridge shop-work, desires position.

E-84 Associate-member, engineering graduate, experienced in general engineering and teaching, desires position for the coming academic year in mechanical department of a technical school.

E-85 Junior member, age 31, considerable experience in foundry and core room operation, equipment design and installation, pattern making, foundry costs, etc., wishes position with large company operating malleable or grey iron foundries. At present employed.

E-86 Member with broad and thorough manufacturing experience from apprentice to general manager in foundry, pattern, machine, blacksmith, boiler shops and drawing office, positions which called for initiative executive ability, tact, the handling of correspondence, organization of men and the direction of their work, wishes employment as manager, superintendent or other executive position. Location immaterial.

E-87 Member, 25 years valuable and complete experience in design and construction of electric traveling cranes, rolling mill machinery, special machinery, etc., desires position as chief designing or mechanical engineer, or in any other capacity where experience would be of value.

E-88 Mechanical engineer, Stevens graduate, age 30, married, seven years varied experience having specialized in pressed steel, both light and heavy; at present holding responsible executive position as plant engineer with small manufacturing concern. Desires a position along similar lines, or one as assistant to superintendent or manager with company offering opportunity for advancement.

E-89 Member, Cornell graduate, age 38, married, nine and one half years experience in railroad shop, testing laboratory, drafting, supervision of power plant and foremen; two years construction work, design and installation of equipment in steel mills, desires position in mechanical department of railroad, manufacturing concern or firm of engineers.

E-90 Factory superintendent or general foreman with broad experience in modern manufacturing methods can produce results with equipment; 12 years experience with production efficiency, organizing, designing tools, and labor saving devices for decreasing of costs.

E-91 Member, technical graduate, with wide experience in design and supervision of heat, light and power plants, also eight years experience in efficiency engineering desires position with consulting engineer or with private firm.

E-92 Junior member, M.E., command of the English and German languages, some knowledge of typewriting and stenography, three years in charge of the mechanical laboratory in a University in the middle West seeks a position with a firm with opportunity for advancement; willing to start at the bottom and work up. Location Eastern states.

E-93 Sales engineer, age 30, married, with wide acquaintance in the South Eastern states, experienced in handling steam, gas, hydraulic and electrical equipment for largest builder in America wishes to locate permanently in his native South in capacity of district manager, or sales agent for similar or allied lines. At present employed but desires change solely for personal reasons.

E-94 Member with experience as superintendent and factory manager thoroughly familiar with modern methods in manufacturing, efficient shop organization and management, desires position.

E-95 Junior member, graduate in mechanical and chemical engineering, four years teaching experience and summer work in power plant, irrigation work, etc., desires position in mechanical-chemical industry. Available after June 15.

E-96 Junior member, graduate mechanical engineer, post graduate work in management and efficiency engineering at Harvard University; drafting room, pattern and machine shop experience, desires position as assistant to works manager or superintendent with an opportunity for advancement by conscientious work and the proper initiative in superintending and increasing the efficiency of production.

E-97 Junior, technical graduate, possessing executive ability, 12 years varied experience in design, construction, operation and maintenance of power houses and sub-stations; familiar with up-to-date methods of mapping and execution of construction and repair orders in power plant and mill accessories, experienced in testing and experimental work, desires position of power engineer, assistant superintendent, assistant manager or works manager. At present employed. Location preferred, New York or vicinity.

E-98 Student member and technical graduate desires employment with engineering or manufacturing company; willing to start in right position at low salary.

E-99 Junior member, mechanical engineer, University of Illinois graduate, age 25, with thorough knowledge of foundry, core and machine shop methods and details, experienced in cost and efficiency work, sales, purchasing, etc., desires position as works manager, or as assistant manager of sales.

E-100 Associate-member, graduate mechanical engineer, 12 years general engineering experience as designer, erection superintendent, assistant general superintendent, consulting and efficiency engineer, would consider position as chief engineer, works manager or similar responsible position with progressive concern.

E-101 Member, 34, married, technical education, 14 years experience in the design, erection and efficient operation of power plants, for past eight years with consulting engineer as principal assistant; up-to-date boiler-room management and efficiency use of exhaust steam a specialty, desires position as mechanical engineer with manufacturing plant, central station or consulting engineer. Location preferred, Eastern states.

E-102 Young man, technical graduate, experienced in engineering, advertising, sales, and practical experience covering power plant operation, foundry, machine shop work and drafting room practice, desires position in advertising or sales department. Salary secondary consideration.

E-103 Mechanical engineer, 1914 graduate, desires position with manufacturing concern or consulting engineers. Will consider any offer with chance for advancement.

E-104 Technical graduate, three years experience in construction work, capable of handling men, would like to get in touch with master mechanic or chief engineer of large manufacturing concern or power company.

E-105 Member, technical graduate, wide training and experience in design of power plants and machinery, construction, maintenance and operation, purchasing engineering material, executive charge of all consulting engineering work, including building construction of all kinds, desires position as works manager or superintendent.

E-106 Member, 25 years practical experience in the design and manufacture of the highest grade of fine interchangeable work. At present employed with one of the largest concerns of its kind in the world as mechanical expert. New York or vicinity preferred.

E-107 Associate-member, age 37, married, with technical training and 17 years practical experience as machinist, draftsman, machine shop foreman and three years instructor of machine shop practice, mechanical drawing and shop mathematics, would consider position for the coming acade-

mic year in technical high school or engineering college. At present employed in a large city vocational school.

E-108 Junior member, seven years experience in economics relating to plant operation, costs, and mechanical and electrical equipment; expert on reports, plans and specifications; writes well on technical and commercial subjects.

E-109 Designing engineer, technical graduate in mechanical engineering, three years practical experience in designing work, has been employed as chief draftsman in high speed steam engine industry and in small factory building, high grade gasoline motors. Now employed in engineering department of large motor car company.

E-110 Mechanical engineer, member, age 38, with shop, designing, sales, executive and business experience desires permanent connection with manufacturer, preferably in Eastern states. Can handle engineering sales, sales office, or executive work in jobbing shops.

E-111 Member, technical graduate, broad experience in factory production work, design, construction and operation of water filtration and sewage disposal plants, consulting engineer, three years experience as district sales engineer, desires position as superintendent or sales manager.

E-112 Mechanical engineer, good personality and character, successful as organizer, executive and production engineer; thorough knowledge and experience in the principles of efficient management, has been associated with best professional exponents of scientific management; fifteen years experience as superintendent, seeks position as factory manager, superintendent or special organizer. At present engaged but desires change.

E-113 Member, A.S.M.E. and A.I.E.E., age 35, technical graduate, E.E. and M.S., 14 years practical experience in the design, construction, operation and maintenance of hydro-electric and steam electric plants, high tension transmission and distribution of electrical energy to mines and cities; estimates, investigations and reports, desires position where experience of this nature will be of advantage. Location immaterial, salary secondary.

E-114 Junior member, age 27, technical graduate, four years experience as mechanical engineer on ore and coal handling machinery, cranes, hoists, monorails and parabolic bins; also experienced in the design of water turbines and similar heavy machinery, desires position as mechanical engineer or estimator with concern who could use man of this experience.

E-115 Member, technically trained, seven years experience in mechanical engineering in foundry machine shop and brass rolling mill work; also ten years with large firm of shipbuilders as leading hull draftsman, inspector and outside man, desires position with engineering firm, or as assistant to superintendent of hull construction at a shipyard. At present employed as mechanical engineer for leading foundry.

E-116 Junior, technical graduate, nine years experience in the design and construction of steam power plants and general engineering, executive charge of the installation of turbine units for municipal lighting and railway service, desires position of similar character such as mechanical engineer for a consulting firm, engineer of construction or power engineer.

E-117 Associate-member A.S.M.E. and A.S.C.E., 13 years experience on design and construction of industrial plants, buildings and bridges, desires position of responsibility in New York or vicinity.

E-118 Student member, Cornell graduate, age 28, married, eight years experience as practical mechanic, toolmaker, master mechanic and tool inspector, desires position with opportunity for advancement, preferably in experimental work, testing, design or as instructor in physics or experimental engineering. At present employed.

E-119 Associate-member, age 30, 15 years practical experience as experimental model maker, draftsman, foreman and production engineer. Experienced as designer on metal working machines and tools. Broad practical experience as factory systematizer having served as junior for one of the foremost industrial engineers in the country, desires position as industrial engineer, superintendent or assistant manager. At present employed as efficiency engineer in plant manufacturing small interchangeable parts.

E-120 Junior, technical graduate, energetic young sales engineer, six years experience in engineering and selling special steel castings, desires position in executive or sales office with a management corporation.

E-121 Graduate M.E., young man with eight years experience as special engineer, superintendent and works manager, 150-300 men. Specialized in production, efficiency and cost methods in the foundry, machine shop and assembly department on both jobbing and repetitive manufacture. Correlative executive experience in plant construction and equipment. Present salary $3,800.

E-122 Member, technical graduate, with commercial training, speaking five languages, fully conversant with Latin and South American trade conditions, 18 years varied experience in design and construction of machinery and buildings, remodeling, maintenance and operation of industrial plants and equipment; systematizing of shops and processes along scientific management lines, testing and general plant engineering; familiar with handling men, drawing up contracts, purchasing equipment and material, appraising properties, modern methods of manufacturing and marketing products, desires to become identified with manufacturing or industrial plant in responsible administrative or executive position. At present employed.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Society of Mechanical Engineers. Report of the Committee to formulate standard specifications for the construction of steam boilers and other pressure vessels and for care of same in service known as The Boiler Code Committee. Rules for the Construction of stationary boilers and for allowable working pressures, 1914. Gift of A.S.M.E.

American Society of Mechanical Engineers. Year Book 1915. *New York, 1915.* Gift of A.S.M.E.

Automobile Club of America. Year Book 1914. *New York, 1914.* Gift of Club.

Carnegie Foundation for the Advancement of Teaching. Case Method in American law schools. Bulletin no. for 1914. Gift of Carnegie Foundation for the Advancement of Teaching.

Design of Boilers and Pressure Vessels, G. B. Haven and G. W. Sweet. *New York, J. Wiley & Sons, 1915.* Gift of publishers.

Dry Rot in Factory Timbers, 1915. *Boston, 1915.* Gift of Associated Factory Mutual Fire Insurance Companies.

Hancock's Applied Mechanics for Engineers. Revised and rewritten by N. C. Riggs. *New York, The Macmillan Co., 1915.* Gift of publishers.

This is intended as a textbook for engineering students of the junior year. Originally prepared by Professor E. L. Hancock of Purdue University, Professor Riggs has revised the text, introducing much larger use of graphic methods. W. P. C.

How to Finance a Business. 202 proved methods of raising capital. *Chicago, A. W. Shaw Co., 1912.* Gift of publishers.

A very careful analysis of methods of financing, giving bases of credit and general financial methods leading to success. W. P. C.

Instruction Papers on Foundry Practice, Thos. D. West. Gift of author.

Motortankschiff "Wotan." Gift of W. R. Haynie.

New York Board of Estimate and Apportionment. Monthly Bulletin of Tests made in Laboratories conducted by the City of New York upon samples taken from Deliveries of Materials and Supplies, Dec. 1914. Gift of Board of Estimate and Apportionment.

Pennsylvania. Water Supply Commission. Annual Report, 1913. *Harrisburg, 1914.* Gift of Pennsylvania Water Supply Commission.

Printed Engineering Resources, J. M. Telleen. Reprinted from Bulletin of the Society for the Promotion of Engineering Education, vol. 5, Nov. 1914. Gift of author.

Railway Economics. A collective catalogue of books in fourteen American libraries. *Chicago, University of Chicago, 1912.* Gift of Bureau of Railway Economics.

Seal of Safety. 1914, 1915. Year book of Max Ams Machine Co. Gift of Julius Brenzinger.

Sperry Gyro-compass and Navigation Equipment. Ed. 2. *New York, 1912.* Gift of Elmer A. Sperry.

Springfield (Mass.) Water Commissioners. Forty-first Annual Report, 1914. *Springfield, 1915.* Gift of Water Commissioners.

Universidad Nacional de la Plata. Contribución al Estudio de las Ciencias fisicas y matematicas. (Serie Tecnica. Vol. 1, no. 1.) *La Plata, 1915.* Gift of Universidad Nacional de La Plata.

GIFT OF AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Carnegie Institute of Technology. General Catalogue 1913-14. Engineers' Club of New York. Constitution, Rules, List of Members, 1914.

Imperial College of Science and Technology, London. Calendar, 1914-15.

——— Goldsmiths' Company's Extension of the City and Guilds (Engineering) College, W. E. Dalby. 1914.

——— Booklet giving information as to industrial careers for young men.

Ohio University. Souvenir edition of Bulletin, Summer 1914.

Princeton University. Catalogue 1913-14.

University of Cincinnati. Annual Catalogue 1913-14.

Western Society of Engineers. Year Book 1914.

Grosse Männer der Naturwissenschaften und der Technik. Verein Deutscher Ingenieure.

100 Jahrigen bestehen der firma Krupp und der Gussstahlfabrik zu Essen-Ruhr, 1812-1912.

EXCHANGES

Concrete Silos. Association of American Portland Cement Manufacturers. Bulletin no. 21. *Philadelphia, 1915.*

Municipal Engineers of the City of New York. Constitution, By-laws, List of Members and Annual Report, 1914. *New York, 1914.*

Sächsischer Dampfkessel Ueberwachungs Verein Chemnitz. Ingenieur Bericht, 1914. *Chemnitz, 1914.*

U. S. Naval Observatory. American Ephemeris and Nautical Almanac, 1917. *Washington, 1915.*

## UNITED ENGINEERING SOCIETY

American Year Book, 1914. *New York-Lond. 1915.*

Carnegie Library of Pittsburgh. Men of Science and Industry. A guide to the biographies of scientists, engineers, inventors and physicians. *Pittsburgh, 1915.* Gift of Carnegie Library of Pittsburgh.

Cast Iron Pipe. Standard Specifications, dimensions and weights. 1914. *Burlington, N. J., 1914.* Gift of United States Cast Iron Pipe and Foundry Co.

Construction of Masonry Dams, Chester W. Smith. *New York, 1915.*

Dewey Decimal Classification. Ed. 8. *Lake Placid Club, N. Y., 1913.*

Eagle Almanac, 1915. *Brooklyn-New York, 1915.*

Electric Vehicle Association of America. Papers, Reports and Discussions of Second Annual Convention, 1911. Gift of Association.

Die elektrischen Metallfadenglühlampen, C. H. Weber. *Leipzig, 1914.*

Engineering Geology, Heinrich Ries and T. L. Watson. *New York, 1914.*

Entwerfen einfach bewehrter Eisenbetonplatten, M. Preuss. *Berlin, 1914.*

Geological and Statistical Map of Brazil. Gift of Consul General of Brazil.

Handbuch für Eisenbetonbau, F. von Emperger. Band II. Ed. 2. *Berlin, 1915.*

New York Times Index, vol. IV., 1914. *New York, 1914.*

Use of Water in Irrigation, Samuel Fortier. *New York, 1915.*

Utilization of Waste Products, Theodor Koller. Ed. 2. *London, 1915.*

World Almanac and Encyclopedia, 1915. *New York, 1915.*

Das Zelluloid und seine Ersatzstoffe, S. Feitler. *Wien, 1912.*

# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

## ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

John A. Brashear, *President* Calvin W. Rice, *Secretary*

Finance Committee, R. M. Dixon

House Committee, S. D. Collett

Library Committee, L. Waldo

Committee on Meetings, J. H. Barr

Committee on Membership, W. H. Boehm

Publication Committee, C. I. Earll

Public Relations Committee, M. L. Cooke

Research Committee, R. C. Carpenter

Committee on Constitution and By-Laws, Jesse M. Smith

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*Boston:* H. N. Dawes
*Buffalo:* David Bell
*Chicago:* S. G. Neiler
*Cincinnati:* J. B. Stanwood
*Los Angeles:* Walter H. Adams
*Milwaukee:* L. E. Strothman
*Minnesota:* Wm. H. Kavanaugh
*New Haven:* H. B. Sargent
*New York:* Edward Van Winkle
*Philadelphia:* H. E. Ehlers
*San Francisco:* C. R. Weymouth
*St. Louis:* Edward Flad

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 JUNE 1915 Number 6


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## COMING MEETINGS OF THE SOCIETY

*June* 9, *St. Louis, Mo.* Subject: Needed Improvements in Specifications, by J. B. Emerson.

*June* 16, *St. Louis, Mo.* Subject: Boiler Failures and What the Am.Soc.M.E. is Doing to Prevent Them, by E. R. Fish, Secretary of the Heine Safety Boiler Company.

Spring Meeting, Buffalo, N. Y., June 22-25.

# THE JOURNAL OF
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Volume 37 June 1915 Number 6

## THE SPRING MEETING

BUFFALO, JUNE 22 to 25

CITY HALL, BUFFALO

THE complete program of the Spring Meeting at Buffalo is published in this number and it is evident that there is not only an attractive group of papers, but that socially the meeting will afford a period of rare enjoyment to those who accept the hospitality of the Buffalo engineers.

Buffalo is not only a city whose industries have developed remarkably during the past few years and thus are of unusual interest to visiting engineers, but it is a city of beautiful avenues and parks and is always attractive to the visitor. Its proximity to Niagara Falls adds still further to the opportunities for pleasure during a stay in the city, and the Local Committee have perfected plans so that every one may enjoy to the utmost the attractions which Buffalo and its environs provide.

It will be noted from the program that there are three periods for professional sessions, on Wednesday, Thursday and Friday mornings, leaving the afternoons free for excursions.

On Tuesday evening there will be interesting addresses of welcome and response respectively by Mr. Frank B. Baird of Buffalo and Dr. John A. Brashear, President of the Society, and refreshments will be served by the local members of the Society and the members of the Engineering Society of Buffalo.

The day Wednesday will be spent at Niagara Falls, the party going there by special electric cars and holding its morning session in the auditorium of the Shredded Wheat Biscuit Company's factory. The return trip will be in time for dinner in Buffalo and an evening lecture by Dr. F. H. Newell, formerly Chief of the United States Reclamation Service, who will speak on the Engineer as a Citizen and illustrate his address with beautiful colored lantern slides.

On Thursday, besides various excursions, the ladies are to be entertained by an automobile trip, and tea is to be served by the Twentieth Century Woman's Club, to which both the members and the ladies are invited. In the evening there will be the reception and dance, when there will be an opportunity to meet socially many of the people in Buffalo.

It is expected that a delegation from Cleveland will come by boat and will be present during the day Thursday.

On Friday afternoon there will be still further opportunities offered for visits to points of engineering interest.

The arrangements for the meeting have been in the hands of the Meetings Committee, John H. Barr, Chairman, and several Buffalo committees, the chairmen of which are as follows: David Bell, General Committee; D. W. Sowers, Finance Committee; H. P. Parrock, Reception Committee; David C. Howard, Entertainment Committee; W. H. Carrier, Hotel Committee; John Younger, Printing and Publicity Committee; Mrs. William Henry Barr, Ladies Committee.

The time for the meeting is such that the commencement season of the colleges will be over, so that a large representation of college men is expected, and it is believed that the accessibility of Buffalo from sections of the country where a large percentage of the membership of the Society is located, will result in a large attendance. It is assured that every member who attends will feel well repaid and count the meeting as a time of great profit and pleasure.

# PROGRAM OF THE SPRING MEETING

HEADQUARTERS AT HOTEL STATLER, JUNE 22 TO 25

*Tuesday, June 22, Buffalo*

2:00 p.m. Opening of headquarters and registration.
*Mezzanine Floor*

6:00 p.m. Conference and dinner of officers and representatives of local sections and the Local Sections Committee.

8:30 p.m. Informal reception and reunion.
*Ball Room, Second Floor*

An address of welcome will be made by Mr. Frank B. Baird, representing the industries of Buffalo, to which Dr. John A. Brashear, President of the Society, will respond. The evening will afford an opportunity for the reunion of members and their reception by the Buffalo engineers. Refreshments will be served.

*Wednesday, June 23, Niagara Falls*

9:00 a.m. The party will leave Hotel Statler by special trolley cars for Niagara Falls. Price for the round trip, including the Gorge Route, $1.25.

10:30 a.m. Business Meeting. Report of Tellers on Amendment to Constitution. Presentation from the Council of proposed amendments to C 53 and C 48 of the Constitution. Reports of professional committees.
*Auditorium of The Shredded Wheat Co.'s Factory*

PROFESSIONAL SESSION FOLLOWING BUSINESS MEETING

The Study of a Shaft and Its Improvement by Heat Treatment, John Younger

A Comparison of the Properties of Nickel, Carbon and Manganese Steel, Robert R. Abbott

Use of Corrugated Furnaces for Vertical Fire-Tube Boilers, F. W. Dean

On Measuring Gas Weights, Thos. E. Butterfield.

During the morning the ladies will have time at their disposal to visit the Shredded Wheat Company's factory and the plant of the Falls Chocolate Company, as well as to enjoy the outdoor surroundings of the Federal Reservation at the brink of the Falls.

1:00 p.m. Luncheon at the International Hotel, price 75 cents.

*Wednesday Afternoon, Niagara Falls*

2:30 p.m. Special cars will be provided for those who desire to take the Gorge Route trip, the price for which is included in the round-trip ticket from Buffalo. There will be an opportunity for those who do not take this trip to inspect the power plants both on the Canadian and American sides, or to enjoy the scenic beauties of Niagara Falls and Goat Island.

5:00 p.m. The special cars for Buffalo will leave the International Railway Station.

*Wednesday Evening, Buffalo*

8:30 p.m. Illustrated lecture on "The Engineer as a Citizen," by Dr. F. H. Newell, formerly Chief of the U. S. Reclamation Service.
*Ball Room, Second Floor, Hotel Statler*

*Thursday, June 24, Buffalo*

10:00 a.m. Simultaneous professional sessions.

PROFESSIONAL SESSION

*Ball Room, Second Floor, Hotel Statler*

Rational Design and Analysis of Heat Transfer Apparatus, E. E. Wilson

Influence of Disk Friction on Turbine Pump Design, F. zur Nedden

Surface Condensers, C. F. Braun

SIMULTANEOUS SESSION

*Assembly Room, Second Floor, Hotel Statler*

Some Mechanical Features of the Hydration of Portland Cement and the Making of Concrete as Revealed by Microscopic Study, Nathan C. Johnson

Design of Rectangular Concrete Beams, Howard Harding

Model Experiments and the Forms of Empirical Equations, Edgar Buckingham

The Effect of Relative Humidity on an Oak Tanned Leather Belt, W. W. Bird and F. W. Roys

11:00 a.m. Automobile ride for the ladies through the city and its environs and the park system.

*Thursday Afternoon, Buffalo*

2:00 p.m. Council Meeting.
*Assembly Room, Second Floor, Hotel Statler*

2:00 p.m. Parties will leave the hotel to visit manufacturing plants and points of interest.

5:00 p.m. Tea will be served for the ladies and members by the Twentieth Century Woman's Club at their Club House, 495 Delaware Avenue.

*Thursday Evening, Buffalo*

9:00 p.m. Reception and dance.
*Ball Room, Second Floor, Hotel Statler*

This will be the leading social function of the Spring Meeting. It is expected that many residents of Buffalo will attend as well as their visiting friends. A collation will be served. Invitations will be sent to all who register at headquarters, which, to be valid, must be endorsed at the registration desk and for which there will be a charge of $2.50 per person.

*Friday, June 25, Buffalo*

10:00 a.m. Professional Session.
*Ball Room, Second Floor, Hotel Statler*

Laws of Lubrication of Journal Bearings, M. D. Hersey

Expense Distribution, H. L. Gantt

Laps and Lapping, W. A. Knight

This is the last session, but it is planned that any who desire may visit manufacturing plants during the afternoon and the Local Committee will be pleased to provide guides for this purpose.

## PAPERS FOR THE SPRING MEETING

Brief abstracts of the papers for the Spring Meeting which had been assigned up to the time of going to press were printed in the last number of The Journal. In this issue the complete list of papers is given in the program and abstracts follow of those which were not listed in the May number. These papers are of a high order of merit and are miscellaneous in character, treating of a variety of subjects. All of these papers will be printed in pamphlet form for distribution in advance of the meeting and copies of any or all of them will be sent gratis to members applying *to the Secretary* prior to the meeting. Application should be made as soon as possible to insure delivery before the meeting. After the meeting extended abstracts of the papers and an account of the proceedings, with discussion, will appear in The Journal so that members will have early information concerning the events of the meeting. Finally, the papers, together with the discussion, will be printed in complete form in the annual volume of Transactions for 1915 for permanent reference.

Albright Art Gallery
One of the Largest and Most Attractive in the United States

Historical Society's Building

Stone Arch Bridge

Scenes in Delaware Park, one of Buffalo's Beautiful Park Centers

## A COMPARISON OF THE PROPERTIES OF NICKEL, CARBON AND MANGANESE STEEL

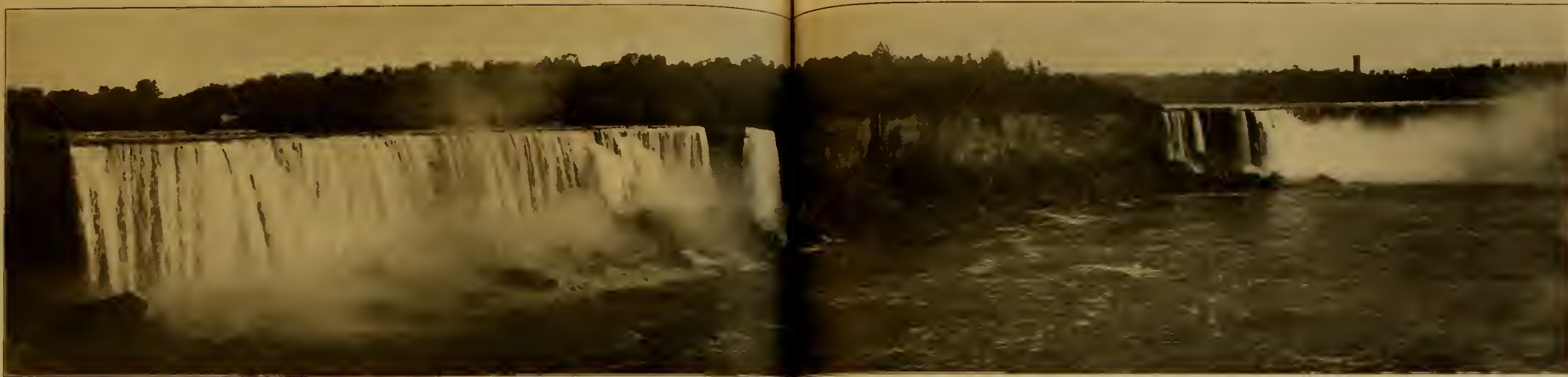
By Robert H. Abbott

This paper gives a comparison of the physical properties, both in the annealed and heat-treated state, of three steels of the same carbon contents, the first of which is an ordinary carbon steel, the second a nickel steel, and the third a manganese steel containing 1.6 per cent manganese.

Test bars of each kind were quenched from slightly above the upper critical points and were then reheated, or drawn at varying temperatures from 300 deg. fahr. to 1300 deg. fahr. The results of these tests are given in the form of charts for comparison. The elastic limit, ma imum strength, reduction in area, elongation and Brinell hardness are compared. Equations are developed, giving these results in terms of the temperature of draw.

Tests were then made comparing the effects produced upon the physical properties by quenching from various temperatures above and below the upper critical points. These results are given in the form of charts.

Conclusions: In the three steels under comparison, it required three times as much nickel as it did of manganese to give the same increase in physical strength. In the un-



*The Whole Day Wednesday, June 23, will be Spent at Niagara Falls Where the first Professional Session will be held*

heat-treated steels, the increase in strength was not accompanied by a decrease in toughness; rather the reverse. In the heat treated steels this increase in strength is accompanied by an increase in toughness, with the nickel steel, while with the manganese steel it is accompanied by a decrease in toughness.

## ON MEASURING GAS WEIGHTS

By Thomas E. Butterfield

The author believes that gas quantities should be expressed in weight rather than in volume measure. Where the performance of different sets of apparatus for generating, burning, compressing or exhausting gas is to be justly compared, density must be determined. This makes it natural to express quantity as weight, volume measures also being given, but as of subordinate interest.

It is also suggested that where chemical analysis is used to determine the proportions of the various materials entering a combustion process, a method of computation be standardized which depends on the determination of the weights of each chemical element entering the reaction. An illustrative example is given.

## ON THE LAWS OF LUBRICATION OF JOURNAL BEARINGS

By M. D. Hersey

In order to establish a rational basis for bearing design, it would be desirable to have empirical equations, or curves, showing accurately and completely how the friction loss and load-carrying power of bearings depend on all the physical conditions governing the action of lubrication, including, of course, the size, shape, and fit of the bearing, the speed, degree of lubrication, properties of the lubricant, and characteristics of the cooling system. The problem of mapping out the laws of lubrication in this general way, whether by piecing together existing data or by making new experiments, is such a complicated one that it is worth while to stop and consider whether any general principles are available which may serve to simplify it.

A recognition of the above facts has led to the present paper, the object of which is first to reduce the problem to a physical basis by suitable definitions and restrictions, and then to develop certain general relations which will simplify the solution of the problem. These relations are of two sorts and may be summarized as follows:

*a* The general forms of the laws of lubrication are deduced by dimensional reasoning, and the characteristic properties of dynamically similar bearings are discussed in the paper.

*b* A distinction is pointed out between the "characteristic" i.e. purely dynamical equations, and the "working" equations needed in the final design of a bearing. It is then shown that the dynamical characteristics of the bearing, and the thermal characteristics of the lubricant and the cooling system are three independent parts of the problem which may be separately investigated, thus greatly diminishing the number of combinations of conditions needed for mapping out the laws of lubrication over the full range of all the variables involved. Finally a general method has been outlined for deducing the desired working equations by utilizing the results of these three investigations as shown.

The paper closes with an analysis of the "ideal bearing," i.e. one which is perfectly circular in cross section, etc. In this connection Sommerfeld's results are reproduced in a convenient form for practical use, and extended by a treatment of heating effects. While intended primarily as a particular illustration of the foregoing general relations, the equations and curves of the ideal bearing doubtless afford a first approximation to the laws of lubrication of actual bearings.

## EXCURSIONS TO INDUSTRIAL PLANTS

On Thursday and Friday afternoons there will be no professional sessions at the Spring Meeting and parties will be made up to visit the various industrial plants of Buffalo and vicinity, cordial invitations from which have been received by the Local Committee. In the last number of The Journal accounts of several of these plants were published, with illustrations of some of them, and invitations have since been extended by several firms referred to below. The list of plants to be visited includes the following: The Lackawanna Steel Company; Buffalo Foundry and Machine Company; Larkin Company, the mail-order house; Wickwire Steel Company; Pratt and Lambert Company, varnish manufacturers; Snow Steam Pump Works; Pierce-Arrow Motor Car Company; Pratt and Letchworth Company, Bingham and Taylor Company, The Aluminum Castings Company, and the D. W. Sowers Manufacturing Company, all engaged in foundry work; the Buffalo Forge Company; the Simonds Manufacturing Company, manufacturer of saws; the Roycroft Shops, East Aurora; the power plants at Niagara Falls where are also the Shredded Wheat Biscuit Company, the Falls Chocolate Company and the large number of electro-chemical industries, which latter, however, for the most part are not open to the public. Besides these firms there are the four referred to below.

### AMERICAN RADIATOR COMPANY

Buffalo manufactures more heating apparatus than any other city in the world. Here are located three large plants of the American Radiator Company, and also their Institute for Thermal Research. National advertising has made their heating systems well known to almost everyone.

### THE J. P. DEVINE COMPANY

The J. P. Devine Company of Buffalo has specialized in the introduction and development of the use of the vacuum drying and impregnating apparatus in this country, and its installations are extensively used in the chemical and allied industries. By reason of its extended experience in supplying standard and special equipment to the chemical industries, and because of its German connections, this company has been able to develop special facilities in supplying autoclaves, digestors, nitrating and sulphonating kettles, rectifying columns, etc., used in the manufacture of benzol, aniline, touluol and other products that have been heretofore obtained from Europe. Members of the society will be accorded a cordial reception at this plant and will find there much that is of interest.

### THE CROSBY COMPANY

Buffalo is also the home of The Crosby Company, makers of sheet metal stampings for a variety of purposes, including those used in automobiles, motor cycles, bicycles, cream separators, lawn mowers, etc. In addition, they design, build and install special machinery for producing difficult pieces of metal stamping. Their plant is exceptionally large and well equipped, and should be inspected by all visiting engineers.

### GOULD COUPLER COMPANY

At Depew, just outside of Buffalo, is located the plant of the Gould Coupler Company, manufacturers of railway couplers, truck frames, general steel castings, electric train lighting systems and storage batteries. The plant is a large one, giving employment to some 3000 men, and embraces production work of unusually interesting character in a variety of different lines. A cordial invitation is extended to the visiting engineers to inspect their works and it is hoped that a large number may be able to take advantage of the opportunity.

## HOTELS AND TRANSPORTATION

The hotels at Buffalo recommended by the Local Committee for guests attending the Spring Meeting, with rates, are as given below. Members should make reservations by writing direct to the hotel at which they desire to stay during the convention.

HOTEL STATLER, HEADQUARTERS FOR THE SPRING MEETING

Single room with bath, $2.50 to $4.50.
Single room with shower bath only, $2.00.
Double room with bath, $4.00 to $6.00.
Double room with shower bath only, $3.00 to $4.00.
Double room with tub and shower bath, $4.00 to $7.00.

HOTEL IROQUOIS

Single room with bath, $3.00 to $5.00.
Single room with shower bath only, $2.50 to $3.00.
Single room without bath, $2.00 to $3.00.
Double room with bath, $5.00 to $7.00.
Double room with shower bath only, $4.00 to $5.00.
Double room without bath, $3.00 to $4.00.

LAFAYETTE HOTEL

Single room with bath, $2.50 and upwards.
Single room with shower bath only, $2.00 and upwards.
Single room without bath, $1.50 and upwards.
Double room with bath, $4.00 and upwards.
Double room with shower bath only, $3.50 and upwards.
Double room without bath, $3.00 and upwards.

HOTEL LENOX

Single room with bath, $2.50.
Single room without bath, $1.50.
Double room with bath, $3.50.
Double room without bath, $2.50.

The Iroquois and Lafayette hotels are located near the Hotel Statler. The Hotel Lenox is a large family hotel pleasantly situated on North Street at Delaware Avenue, in the residential district. Visitors desiring to register at the latter should take a Miller Transfer Company's taxicab at the station and instruct the driver to charge the service to the hotel.

TRANSPORTATION

The present arrangements of the railroads with regard to transportation of those attending conventions are such that no material reduction can be secured, and no effort will be made by the Society to organize parties for the trip to and from Buffalo except as members going on a particular train may wish to leave their names at the Society headquarters for the benefit of others who may wish to travel on the same train. Each person will be required to pay full rate for transportation.

## VOTE ON THE SOCIETY'S PUBLICATIONS

In accordance with a resolution passed at the last Annual Meeting and a subsequent resolution of the Council, a vote of the entire membership is to be taken on the question of the publications of the Society. It was expected that ballots for this purpose would have been issued before now, but it was decided to defer the matter until a report could be made upon the publications by the Administration Committee. This Committee was appointed in January to "investigate and report back to the Council at an early date upon the economical operation of the Society's administration and also that of the Council." These investigations extend into the various activities of the Society, including the publications, looking to the greatest possible usefulness to the membership as well as the economical administration of the various departments.

In this connection it may be stated that the publication plan which is now being followed includes the publication of the annual volume of Transactions in the 6 x 9 size, as heretofore. Papers presented at the Spring and Annual Meetings are printed in pamphlet form in advance of the meeting and are sent gratis to members requesting them previous to the meeting, due announcement of the papers being made in The Journal.

Following a meeting extended abstracts of the papers are printed in The Journal, together with an account of the discussion, so that the reader may be informed promptly what transpired; and finally the complete, revised papers and discussion appear in the annual volume of Transactions.

Besides this material The Journal contains very complete accounts of the local meetings of the Society, which are now held at intervals in fourteen different cities and which bring to The Journal a large number of valuable papers secured through the efforts of the committees in different sections of the country. An important feature of these papers in relation to the membership at large is that they present the latest engineering developments in the particular locality where the meeting is held, which strengthens the national character of the Society and the comprehensive scope of the papers which it is the privilege of The Journal to publish.

Besides these varied papers The Journal contains from month to month announcements and reports of the Society's activities which, through its committees, are reaching out into broader fields of usefulness. The Journal contains also a review section, including abstracts of foreign articles, and in spite of the curtailment of foreign publications, owing to the unfortunate conditions existing at the present time, this department is able to present from month to month much valuable material on engineering practice.

## COUNCIL NOTES

At the meeting of the Council on May 14, 1915, Major William H. Wiley was appointed Chairman and John A. Hill, Vice-Chairman, to represent the Society on a joint committee of the engineering societies, coöperating with the United States Government and Army in the organization of a civilian corps of engineers. These members of the committee are to choose their associates, making a committee of five.

Announcement was made of the appointment of C. M. Allen, Charles T. Main and W. M. White as a committee to consider the merits of a suggested government water wheel testing flume and to report back to the Council.

*Voted:* That one session of the annual meeting in New York, December 1915, be set aside for a memorial meeting to Frederick W. Taylor, and that a committee composed of Past-Presidents Henry R. Towne, Chairman, Frederick R. Hutton, Alex. C. Humphreys, John R. Freeman and Oberlin Smith, be in charge of this session, at which it is suggested one principal paper be presented to include an account of Mr. Taylor's life and the development of such phases of his work as the Committee may deem proper.

*Voted:* That Francis H. Richards, W. H. Boehm and H. de B. Parsons be appointed on the Committee on Expert Testimony, coöperating with the American Association for the Advancement of Science, with the request to add two other members of their own choosing.

*Voted:* In connection with the resolution of the Council of April 9, to refer to the Committee on Public Relations with request to report recommendations to the Council, as a "special committee of five to formulate general principles for the guidance of those who may serve the Society in a representative capacity, and particularly when dealing with public questions."

It was voted to approve an appropriation of $250 towards the development of a Search Bureau in the Library of the United Engineering Society.

*Voted:* To express to H. de B. Parsons the appreciation of the Council for his report on Fire Hose Specifications, covering the result of appointment as the representative of the Society on a special committee appointed by the Fire Department of the City of New York.

The Secretary read a letter from E. G. Spilsbury reporting the action taken by the engineers committee from the several societies on the constitutional convention. Prof. A. M. Greene, Jr., also reported that the committee had appeared before the convention, that Senator Root had received them and given them a hearing, with the result that the committee is now endeavoring to have these suggestions drafted in the form of various amendments.

*Voted:* To approve as a committee on meetings in Philadelphia, Robert H. Fernald, Chairman, W. R. Jones, Secretary, E. B. Carter, H. E. Ehlers, J. E. Gibson and A. C. Vauclain, and to approve the appointment of F. W. Gay as a member and Secretary of the committee on meetings in San Francisco to take the place of C. T. Hutchinson who has resigned.

Professor Hutton read a letter acknowledging the receipt by the Institution of Naval Architects, of the draft for 60 pounds, being the amount subscribed by members of the Society and friends of Sir William H. White, toward a memorial fund to honor his memory.

## INTERNATIONAL JURY OF AWARDS

### PANAMA-PACIFIC INTERNATIONAL EXPOSITION

The group Juries of Award of the Panama-Pacific International Exposition have been in session at San Francisco during the month of May and several members of the Society have served in the various groups, of which the following is as complete a list as we have at present: Guy L. Bayley, George M. Brill, George W. Dickie, Paul Doty, John T. Faig, H. W. Hibbard, John Hunter, Charles T. Hutchinson, Wm. H. Kavanaugh, Frederick R. Low, Charles E. Lucke, Wynn Meredith, Thomas Morrin, C. P. Poole, Calvin W. Rice, Angus Sinclair, Jesse M. Smith, Bradley Stoughton and Max Toltz. The classification of the machinery exhibits is as follows:

| | |
|---|---|
| Group 85 | Steam Generators and Motors Utilizing Steam. Accessory Appliances |
| Group 86 | Internal Combustion Motors. |
| Group 87 | Hydraulic Motors. |
| Group 88 | Miscellaneous Motors. |
| Group 89 | General Machinery and Accessories. |
| Group 90 | Tools for Shaping Wood and Metals. |

There are three Juries for the machinery exhibits, aside from the electrical apparatus, of which the officers are as follows:

Group 85 to 88 inclusive, Charles E. Lucke, Chairman, H. W. Hibbard, Secretary.

Group 89, George M. Brill, Chairman, Calvin W. Rice, Secretary.

Group 90, George W. Dickie, Chairman, John T. Faig, Secretary.

## PUBLICATION OF THE BOILER CODE

The Boiler Code which was published in pamphlet form the first of March will be sent to every member of the Society in the annual volume of Transactions, to be distributed during the coming summer. In view of its publication in Transactions and of the availability of the report in pamphlet form it is not intended to reprint the report in The Journal. Those desiring pamphlet copies may secure them at 40 cents per copy to members (and to organizations), and 80 cents per copy to non-members. These prices apply to lots of less than 1000. In lots of 1000 to 2000 the price is 30 cents per copy, and in lots of 2000 or over the price is 20 cents per copy, f.o.b. printer, Lyons, N. Y.

## PORTRAIT OF ALFRED NOBLE

On April 22 a portrait of the late Alfred Noble, painted by Alphonse Jongers, was unveiled at the Engineers' Club in New York. The portrait is an excellent likeness and fittingly commemorates the personality of the engineer who was so widely known among the profession throughout the country. He was a frequenter of the Engineers' Club, where he met his friends from day to day. Addresses were made at the unveiling by Stevenson Taylor, J. Waldo Smith, Professor Hutton and H. F. DuPuy.

## AWARDS OF THE FRANKLIN MEDAL

The Franklin Medal, the highest recognition in the gift of The Franklin Institute, Philadelphia, has recently been awarded to Heike Kamerlingh Onnes, and to Thomas Alva Edison, Mem. Am. Soc. M. E. The awards were made on the recommendation of the Institute's Committee on Science and the Arts, that to Onnes being in recognition of his "long-continued and indefatigable labors in low-temperature research which has enriched physical science, not only with a great number of new methods and ingenious devices, but also with achievements and discoveries of the first magnitude," and that to Edison in recognition of "the value of numerous basic inventions and discoveries forming the foundation of world-wide industries, signally contributing to the well-being, comfort and pleasure of the human race."

The Franklin Medal Fund, from which this medal is awarded, was founded on January 1, 1914, by Samuel Insull. Awards of the medal are to be made annually to those workers in physical science or technology, without regard to country, whose efforts, in the opinion of the Institute, have done most to advance a knowledge of physical science or its applications.

The present awards are the first to be made.

The medal awarded to Professor Onnes was received on his behalf by His Excellency, Chevalier van Rappard, Minister from the Royal Netherlands Government, at the stated meeting of the Institute on the evening of Wednesday, May 19, and at this meeting Mr. Edison was the guest of the Institute and received his award in person. Following the presentations, an address entitled "Electricity and Modern Industrial Growth" was delivered by Mr. Insull.

## ANNIVERSARY OF WORCESTER POLYTECHNIC INSTITUTE

The Fiftieth Anniversary celebration of the Worcester (Mass.) Polytechnic Institute will occur from June 6 to 10 in connection with the Commencement exercises, and the character of the celebration will be such as to make the event also a celebration of the achievements of engineering and science.

On Wednesday, June 9, there will be addresses by engineers of international reputation, following which there will be a special meeting of the Local Section of The American Society of Mechanical Engineers, and a banquet in the evening.

General George W. Goethals has accepted an invitation to be present and speak upon the part the civilian engineer has taken in America's outlying possessions, and it is hoped that President Wilson, who was the commencement orator twenty-five years ago and has expressed a desire to attend, may be able to be present. Addresses will also be made by Dr. John A. Brashear, President Lowell of Harvard and Governor Walsh of Massachusetts, and others of wide reputation.

## BOILER CODE IN EFFECT IN OHIO

Those who have been interested in the work of the Boiler Code Committee and the development of the Code, the completion of which was announced in The Journal for March, will be interested to learn that it has been put into effect in the State of Ohio. At a meeting of the Ohio Board of Boiler Rules held on March 25, the Code was placed in force by the adoption of the following resolution:

Until further notice an inspector holding a certificate of competency and a commission authorizing him to inspect steam or hot water boilers which are to be installed within the State of Ohio, is hereby authorized to inspect during construction and on completion stamp Ohio STD with serial number any boiler constructed in accordance with the rules formulated by the Boiler Code Committee as submitted to the Council of the American Society of Mechanical Engineers on February 13, 1915.

(Signed) Ohio Board of Boiler Rules,
H. V. Neff, Chairman.

The State of Ohio has had in force for some time a code of boiler rules which has been very satisfactory, and in consequence, this action is certainly a very strong endorsement of the A. S. M. E. Boiler Code. It should assist very greatly in securing the adoption of the A. S. M. E. Code in other states.

The Boiler Code has also been further endorsed by a meeting of representatives of the American Boiler Manufacturers' Association and of the National Tubular Boiler Association, held in Pittsburgh on March 29, where the report of the Boiler Code Committee was unanimously adopted and ways and means were discussed for promoting the adoption of the standard specifications by the various states. This meeting gives to the Boiler Code a tremendous impetus, as it puts back of it the endorsement of practically the entire boiler manufacturing industry. This marks the climax of a continuous effort for twenty-five years to get a standard specification that would be acceptable to engineers, manufacturers and users of boilers and boiler insurance companies, and these actions would indicate that the Code is in itself as nearly right from a mechanical and engineering standpoint as it is possible to construct such a code.

## CLASSIFICATION OF TECHNICAL LITERATURE

Delegates from about twenty national technical and scientific societies met in the United Engineering Society Building, New York, on May 21, to perfect a permanent organization, the purpose being to prepare a classification of the literature of applied science which might be generally accepted and adopted by these and other organizations.

There was a generally expressed opinion that such a classification, if properly prepared, might well serve as a basis for the filing of clippings, for cards in a card index, and for printed indexes; and that the publishers

of technical periodicals might be induced to print against each important article the symbol of the appropriate class in this system, so that by clipping these articles a file might be easily made which would combine in one system these clippings, together with trade catalogues, maps, drawings, blue prints, photographs, pamphlets and letters classified by the same system.

By request, W. P. Cutter, the Librarian of the Engineering Societies' Library, and a delegate from the American Institute of Mining Engineers, read a paper on The Classification of Applied Science, in which, after describing the existing classification, of one of which he is the author, stated that, in his opinion, no one of these, although having excellent features, was complete and satisfactory enough to be worthy of general adoption. He outlined a plan whereby a central office could collate all the existing classifications, and, with the help of specialists in the various national societies interested, might compile a general system which would meet with general acceptance.

The name adopted for this organization is Joint Committee on Classification of Technical Literature, and the officers elected are: Chairman, Fred R. Low; Secretary, W. P. Cutter, 29 West 39th Street, New York; Executive Committee: the above, with Edgar Marburg, H. W. Peck, Samuel Sheldon.

## SAN FRANCISCO MEETINGS

That there may be no misunderstanding in connection with the special train, New York to San Francisco, for the International Engineering Congress and the meeting of the Society in San Francisco in September, the Secretary wishes to announce that the special train under the direction of the committee of the joint engineering societies, is via Niagara Falls. The itinerary of this train is as follows:

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|---|---|
| Thursday, September 9: | |
| Leave New York (Grand Central Terminal).... | 7:45 p. m. |
| Arrive Albany | 11:10 p. m. |
| Leave Albany | 11:15 p. m. |
| Friday, September 10: | |
| Arrive Niagara Falls, N. Y. | 7:30 a. m. |
| Leave Niagara Falls, N. Y. | 11:30 a. m. |
| Arrive Chicago, Ill. | 10:55 p. m. |
| Leave Chicago, Ill. | 11:55 p. m. |
| Sunday, September 12: | |
| Arrive Colorado Springs, Colo. | 7:30 a. m. |
| Leave Colorado Springs, Colo. | 7:00 p. m. |
| Monday, September 13: | |
| Arrive Albuquerque, N. Mex. | 12:15 p. m. |
| Leave Albuquerque, N. Mex. | 1:15 p. m. |
| Tuesday, September 14: | |
| Arrive Grand Canyon, Ariz. | 4:00 a. m. |
| Leave Grand Canyon, Ariz. | 7:00 p. m. |
| Wednesday, September 15: | |
| Arrive San Francisco, Cal. | 9:00 p. m. |

## GENERAL NOTES

An attractive student publication has come to the Secretary in the form of a souvenir number entitled an "Engineer's Special Issue" of the Round-Up, published at State College, New Mexico. This is an eight page paper filled with live matter relating to the college and student activities, but in this issue the bulk of the publication is devoted to the engineering courses and shows by extended articles and numerous half-tone illustrations the work and activities of the engineering school. The publication is unique in its advertising possibilities through its departure from the usual college bulletin.

The inauguration of Edward Kidder Graham as President of the University of North Carolina took place at Chapel Hill, N. C., April 21. He is the tenth president of the oldest state-supported university in the United States and is one of the youngest college presidents. The Society was represented at the inauguration exercises by Park A. Dallis of Atlanta, Ga., who was appointed Honorary Vice-President for the occasion. Among the delegates and visitors who formed the procession were the Governor and Justices of the Supreme Court of North Carolina, Secretary Daniels of the Navy, in addition to the past-presidents and faculty of the University.

Several complaints have come to this office of men who have posed as members of the Society and have attempted to borrow money on the strength of their membership. Three such cases have come to our attention and members are warned that they should be on their guard against such forms of imposition. A person thus representing himself should at least be able to show his membership card as evidence of sincerity.

## APPLICATIONS FOR MEMBERSHIP

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of Grading are also posted. The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before July 10, 1915.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Allen, Jesse B., Ch. Engr. and Master Mech., Tuttle & Bailey Mfg. Co., Brooklyn, N. Y.

Butler, William A., Asst. Supt. Pwr. Stas., Duquesne Light Co., Pittsburgh, Pa.

Biglow, Lemuel Cavalli, Mgr., New York Office, Morse Chain Co. of Ithaca, New York, N. Y.

Bjornsson, Carl A., Desinging Engr., The McIntosh & Seymour Corp., Auburn, N. Y.

Clark, Harold H., Local Mgr., Link-Belt Co., Los Angeles, Cal.

Davisson, Woodford, Ch. Engr., Rancho La Brea Oil Co., Los Angeles, Cal.

Flanner, Douglass D., Treas. and Genl. Mgr., Flanner Water Tube Boiler Co., Akron, Ohio.

Goodwin, E. Clayton, Supt., Hart & Cooley Co., New Britain, Conn.

Greist, Hubert Milton, Secy. and Supt., The Greist Mfg. Co., New Haven, Conn.

Griffith, Leigh M., Mgr. and Co-Partner, Griffith Mch. Wks., Los Angeles, Cal.

Hall, Winthrop G., Asst. Supt., Spencer Wire Co., Worcester, Mass.

Hayes, Ralph W. E., Mech. Engr., Hayes Pump & Planter Co., Galva, Ill.

Hicks, George C., Jr., Vice-Pres. and Engr., P. H. & F. M. Roots Co., Connersville, Ind.

Howe, James F., Asst. to Dist. Mgr., American Steel & Wire Co., Worcester, Mass.

Johnson, Charles L., Clerical Supt., Western Elec. Co., Hawthorne Sta., Chicago, Ill.

Kidd, George F., Engrg. Dept., The New York Edison Co., New York.

Lang, Charles W., Supt., Defiance Mfg. Co., Summerdale, Philadelphia, Pa.

Lawton, B. L., Treas. and Genl. Supt. of Factory, Conn. Tel. & Elec. Co., Meriden, Conn.

Lawton, Charles L., Genl. Mgr., Quincy Mine, Hancock, Mich.

Litchfield, H. L., formerly Elec. Engr., Choralcelo Co., Boston, Mass.

Lord, Zenas N., Dept. Foreman, General Elec. Co., Lynn Wks., West Lynn, Mass.

McGowan, Henry E., Asst. Secy., The Brooklyn Union Gas Co., Brooklyn, N. Y.

Malm, Axel C. V., Supt., The Egry Register Co., Dayton, O.

Maxwell, Howard, Engr., General Elec. Co., Schenectady, N. Y.

Mullin, John T., Mech. Draftsman, Mead-Morrison Mfg. Co., Chicago, Ill.

Park, Edwin Hervey, Asst. to Master Mech., Wright Wire Co., Worcester, Mass.

Perkins, Edwin A., Mech. Engr., The Norma Co. of America, New York.

Scott, Rossiter Stockton, Engr., Consolidated Gas, Elec. Light & Power Co., Baltimore, Md.

Thompson, Charles F., Maintenance Engr., The Aultman & Taylor Mchy. Co., Mansfield, O.

Tyler, Warren C., N. Y. Mgr., Poole Engrg. & Mch. Co., Woodberry, Baltimore, Md.

Wolff, John, Mech. Engr., Cleveland Elec. Ill. Co., Cleveland, O.

#### FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

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### APPLICATIONS FOR CHANGE OF GRADING

#### PROMOTION FROM JUNIOR

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#### PROMOTION FROM ASSOCIATE

Flinn, Charles F., Cons. Engr., San Francisco, Cal.

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# MODERN ELECTRIC ELEVATOR AND ELEVATOR PROBLEMS

BY DAVID LINDQUIST[1], NEW YORK

Non-Member

THE elevator art has gone through quite a number of more or less radical changes, particularly in the last fifteen years. These changes have been partly due to developments in building construction, utilizing steel as building material, thereby making it possible as well as practical to erect high structures. At the same time, it cannot be denied that the simultaneous development of commercial elevators particularly for high speed, has materially aided in the development of modern buildings.

Elevators may be classified according to the driving power employed: Steam driven elevators; Hydraulic elevators, and Electric elevators.

The first class, namely, steam elevators, is at the present time practically obsolete. There are, of course, quite a few of them still in existence and running, but there are no new plants of this type being installed at the present time.

*The tall buildings of New York have been made possible by the development in elevators*

Hydraulic elevators may be divided into several groups, depending upon the different methods in which the hydraulic power is transmitted to the elevator car. Some of the principal and well-known types are: The horizontal hydraulic (rope geared); the vertical hydraulic (rope geared), and the plunger hydraulic (direct connected). These types have been mentioned in the order they were introduced for high speed in comparatively high buildings. The plunger type practically superseded other types of hydraulic elevators during the period of 1904 to 1907, and in turn the plunger has now been almost entirely superseded by the gearless 1:1 traction type of electric elevator.

Without considering in detail the technical features of the plunger elevator in comparison with the gearless electric traction type, the principal reasons for this change in elevator practice may be summarized as follows:

*a* Higher initial cost of a plunger installation.

*b* Larger amount of total space in the building occupied by the machinery.

*c* Lower car mileage and consequently more elevators required for the same service.

*d* Higher power consumption.

The principal features of both the gearless and gear traction type of elevators will be described, the gearless, however, being treated more in detail.

*Location of Machine.* When considering the installation of the traction electric elevator the first question which arises is as to where the machine may most suitably be placed. There is no question but that placing the machine directly over the hatchway, as indicated in Figs. 2 and 3, is the most suitable arrangement. With this overhead location the best results are obtained, and the principal advantages may be enumerated as follows: better traction, less amount of rope, longer rope life, minimum space required, and higher efficiency.

It will be perfectly plain, if one stops to consider, that placing the machine directly over the hatchway will impose less load on the building than if the same machine were placed below. Placing the machine directly above the hatchway imposes a load on the building equal to the weight of the hoisting machine plus the loads on car and counterweight ropes, whereas placing the machine below, imposes a load on the building equivalent to twice the loads on the car and counterweight ropes. For a duty of 2500 lb. at 700 ft. per min., the hoisting machine weighs about 16,000 lb., which is considerably less than the total load on car and counterweight ropes.

In the above example, the machine, due to high speed, is quite heavy in proportion to the load. A machine intended for lower speed would weigh still less and make the difference in loads imposed upon the building, to which attention is called, even more apparent.

Locating the machine above also takes up less space in the building than locating it elsewhere. It also somewhat prolongs the life of the ropes, as by this arrangement the rope is not subjected to so many bends. Placing the machine overhead also increases the overall efficiency of the installation.

*Roping.* The next consideration is that of roping. The roping of a so-called gearless 1:1 traction machine located overhead is extremely simple, as indicated in Fig. 4.

The principle of the traction drive is no doubt very old but its commercially successful application to an elevator

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Presented at the New York local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on April 13, 1914.

machine, consisting of a slow speed electric motor directly connected to the driving sheave, was first accomplished about ten years ago. Some attempts had previously been made, particularly by Duwelius, who built two, or possibly three, machines. For a number of reasons, however, they were not considered practical and he finally abandoned the attempt,

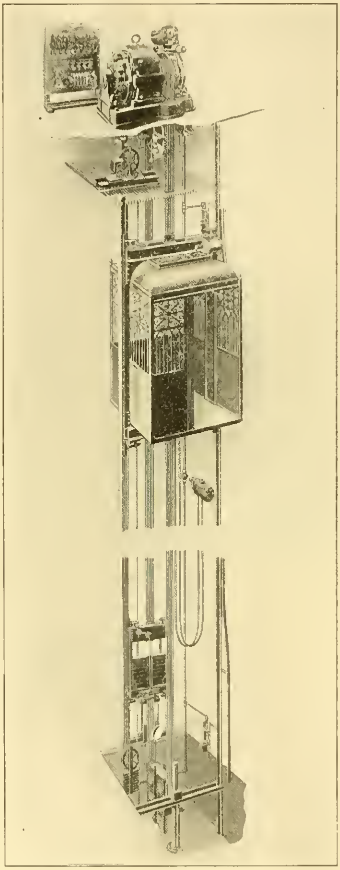


FIG. 2 ARRANGEMENT OF APPARATUS IN A TYPICAL GEARLESS TRACTION ELECTRIC ELEVATOR INSTALLATION

for apparently he could not produce a successful gearless electric elevator machine.

At first glance, it would appear as if the traction drive would be rather uncertain, when considering that the ropes are not actually hitched to the driving member, that they simply go around the driving sheave of the motor, and depend solely upon the friction, or adhesion between the ropes and the driving sheave. This, however, is not the case; on the contrary, it is safer than any other method of drive.

Before any of these traction machines were put on the market, a large number of tests were made under such variable conditions as would be encountered in actual installations. It was found that with one-half wraps around the driving sheave the maximum traction relation—that is, the relation between the load on the heavy side of the ropes to that on the light side—was 1.56, and the minimum traction relation, with one-half wraps was 1.4. With two half wraps as indicated by diagram, Fig. 4, the maximum relation is 2.43 and the minimum 1.96; the increase being of course in logarithmic proportion.

The maximum was obtained with a new turned sheave with practically new ropes and without any lubrication. The minimum was obtained with smoothly-worn sheave and ropes well lubricated, and with comparatively light tension and high speed. The principal reasons for this result are that with light tension and high speed there is an oil film between the rope and the sheave; moreover, the rope does not make contact fully 180 deg. with the sheave, due to the stiffness of the rope and centrifugal action.

The small variation, or the constancy of the traction is quite remarkable, and as long as the maximum variations in

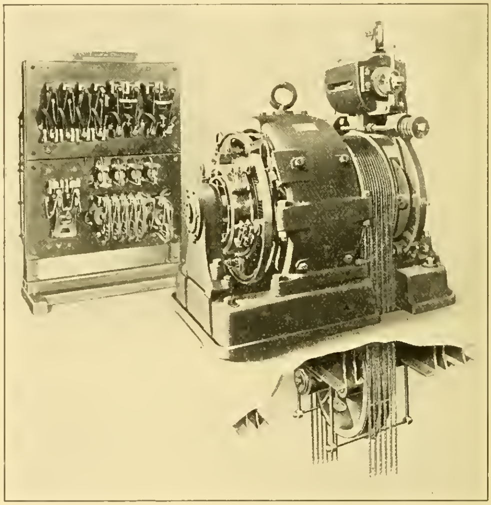


FIG. 3 DETAIL VIEW OF THE OVERHEAD INSTALLATION OF A GEARLESS TRACTION ELECTRIC ELEVATOR

the load on a traction type elevator are such as not to require more than the minimum possible traction relation above mentioned, no slipping can occur.

Under ordinary conditions a 1:1 traction machine is usually provided with six ropes $\frac{5}{8}$ in. in diameter. The material is of soft steel, and in actual installations this will give a safety factor of not less than twelve.

Each rope is provided with a self-adjusting swivel rope hitch of the ball and socket type. This permits a gradual creeping and thus prevents any excessive twisting strain, and relieves the rope of the bending strains at the hitch, principally caused by vibration.

The traction method of drive has a number of inherent safety features. Traction elevators are arranged so that in case of overrun at terminals, either the car or counterweight bottoms on a buffer, thereby reducing the traction sufficiently to pervent further motion of the car and counter-

weight, even if the motor keeps on running. The car buffer is usually an oil buffer of a spring return type and mounted in the bottom of the pit, as illustrated in Fig. 5. As shown in Fig. 4, the counterweight buffer is mounted on the counterweight, and acts also as counterbalance. This latter buffer has gravity return, whereas the car buffer has spring return.

For very high rises, the great weight of the hoisting rope will cause considerable traction, even after the car or counterweight has landed on its buffer. This traction, together with the momentum of the car or counterweight, may cause either of them to travel into the overhead work, under conditions of runby clearance usually available. To prevent this, some of the exceedingly high rise buildings are equipped at the top of the hatchway with a retarding and latching device for both car and counterweight, in addition to the regular oil buffers acting in the pit. In case of abnormal overrun, the retarder brings either car or counterweight to rest and the latching device prevents subsequent downward movement.

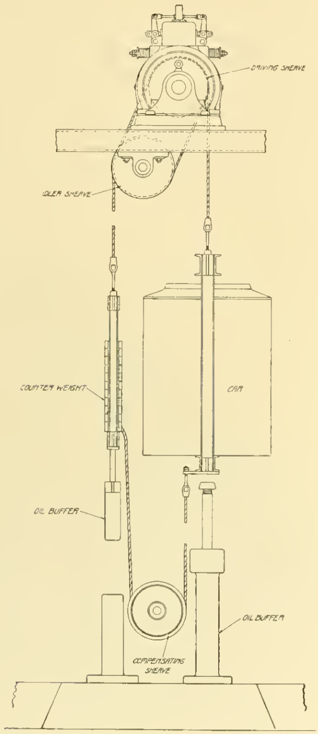



Fig. 4 Details of the Roping of a Typical Gearless 1:1 Traction Elevator

*Counterweight and Rope Compensation.* The counterweight, the mechanical construction of which may be seen in Fig. 2, equals in total weight the weight of the car plus usually about 40 per cent of the maximum load. If we consider an elevator of 2500 lb. lifting capacity, 40 per cent of this equals 1000 lb. (the overbalance) and this represents about six or seven persons. Thus, with six or seven persons in the car, giving balanced condition, it is apparent there would be no *net load* to be lifted and the only power required would be for acceleration and for overcoming friction and electrical losses.

It is obvious that with a high rise elevator the variation in the net load on the elevator machine due to the shifting of the weight of the hoisting ropes from one side to the other of the driving sheave as the car moves up and down, would be excessive if this were not compensated for. This compensation is usually obtained by means of chains or ropes attached to the car and counterweight, and running down the hatch in a loop. In Figs. 2 and 4 may be seen the compensating ropes running down from the bottom of the car to the tension sheave in the pit and up to the counterweight. The weight per foot of these compensating ropes is such that they, together with the electric cables (that lead to the car), will compensate the weight of the hoisting ropes regardless of the position of the car.

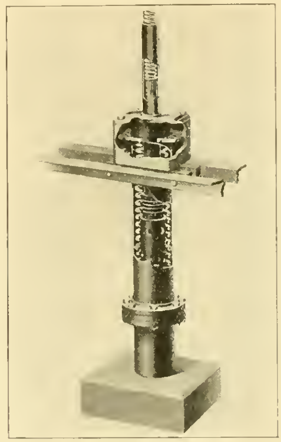


Fig. 5 Detail View of Car Buffer of the Spring Return Type

For all high speed high rise elevators, compensating ropes are used. In the pit a tension device is provided for the compensating ropes. For moderate rises and comparatively slow speeds, chains may be used instead of ropes.

*Driving Motor.* The electric motor is of the slow speed type, generally six pole and usually provided with shunt field only. The armature is series-wound with conductors of rectangular cross section, in order to get the maximum amount of copper in the armature. With a 36 in. driving sheave, a car speed of 600 ft. per min. corresponds to 63.6 r.p.m. of the motor. Figs. 6 to 9 show the compact design of the motor, and Figs. 8 and 9 show machines provided with ball bearings, which it may be seen are shorter than the regular babbitted bearings. The principal features of the motor with driving sheave, commutator, electro-mechanical brake, brake shoes, etc., are clearly illustrated.

Up to even a comparatively late date, it seems to have been the general impression that a motor of moderate duty, having a speed so exceedingly low as that required for this

gearless type of elevator, would have also a low efficiency; but this is not the case. On the contrary, it has been demonstrated, and proven a number of times, that a motor with this low speed can be designed to have just as high efficiency as any high speed motor of equal output. One peculiar feature about the efficiency of this motor is that it is unusually high at light loads. This is particularly of advantage in connection with elevators where the average load on the motor is usually less than one-half its rating.

The curve in Fig. 10 shows the result of a test on a traction motor installed in the Metropolitan Life Tower. This motor was rated at 38 h.p., at which full load capacity an efficiency of 89 per cent may be observed. At half load, the motor shows an efficiency of 91.5 per cent and at quarter load

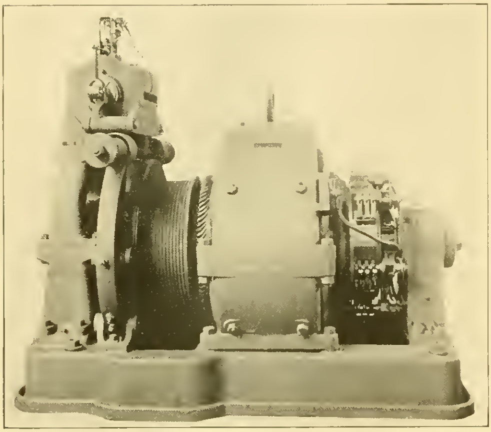


FIG. 6 A TRACTION ELECTRIC ELEVATOR MACHINE OF THE 1:1 TYPE

over 90 per cent. It may be said that these are uncommonly high efficiencies for a motor of 38 h.p. capacity, designed for a speed of 58 r.p.m. at 110 volts.

The curve in Fig. 11 shows the result of a test of a traction motor installed at the 181st St. Subway Station in N. Y. City. This curve shows that the motor has a maximum efficiency of 93 per cent at about half output and illustrates still better the remarkable results that can be obtained with motors of abnormally slow speed for comparatively small outputs. These efficiencies are, as a matter of fact, considerably higher than is usually obtained in high speed motors of corresponding horse power; particularly is this true with light loads. Further reference to motor efficiency will be made in connection with power consumption.

The driving sheave is commonly about 36 in. in diameter, and the driving sheave and brake wheel are of the rim type, cast integral and bolted to the armature sleeve or spider. Circular rope grooves are employed. The brake is of the shoe type, and the magnet is usually provided with series-winding for quick release, and with a shunt-winding for holding. The brake shoes are provided with a lining of fabricated asbestos. A gradual and soft application of the brake is obtained by a particular method of magnetic retardation of the magnet cores, eliminating thereby the necessity for dash pots. The brake shoes were formerly, for some time, lined with leather, but after very exhaustive tests of a number of different brake lining materials, it was found that a certain kind of fabricated asbestos was the most suitable. The particular qualities or characteristics of this brake lining are, that the friction between the lining and the wheel is practically constant at all times. Tests have been made and the temperature ran up to about 400 deg. cent., but there was no appreciable variation in the friction. Furthermore, the coefficient of friction is very constant, varying but little with variations in speed. The variation is remarkably small as compared with leather. With leather, it was frequently noticed that the machine would come almost to a stop, and then creep, just as in the case of a hydraulic elevator with a slight leakage of water. This was due to the fact that the friction coefficient between the leather and the brake wheel was very much lower at slow speed than at high, the minimum being obtained at practically zero speed.

*Bearings.* The bearings are either of the ordinary babbitt lined, self-aligning type, with automatic chain-oiling, or are of the anti-friction type (ball or roller bearings). Elevators of the gearless traction type have been for some time equipped with ball or roller bearings, which are used for both the main motor, and rope sheave bearings. They were

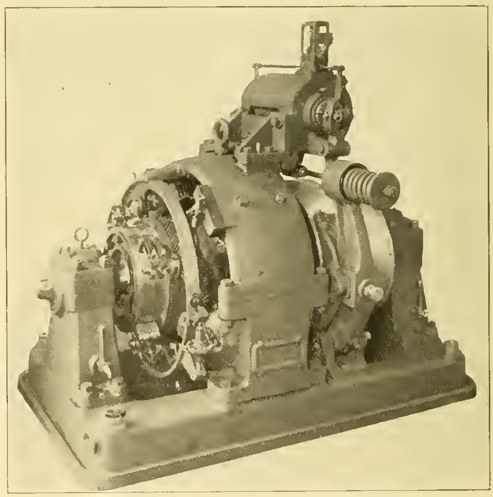


FIG. 7 A TRACTION ELECTRIC ELEVATOR MACHINE OF THE 2:1 TYPE

adopted primarily to gain space, and it is readily apparent that these anti-friction bearings take up much less room than the plain solid bearings. It followed therefore that a traction machine equipped with them could be designed to take up less space, and thus, in many instances, eliminate the necessity for double decking an installation consisting of a number of adjacent elevator machines; by "double decking" is meant the placing of machines on two levels, when the machine is longer than the center distance between adjacent hatchways, thus preventing their installation on one level.

In the case of elevators with 2:1 roping, this saving in space in connection with the sheaves, really becomes a neces-

sity; for here, particularly in the counterweight sheave where space conditions are always limited, a plain babbitted bearing of suitable capacity would be practically impossible. Of course, the use of these anti-friction bearings also introduces other very decided advantages,—materially reducing friction, particularly at starting, and introducing a smoothness of operation superior to plain bearings. This is again particularly applicable to the sheaves used with machines having 2 : 1 roping, for here the additional number of sheaves requires that the friction be reduced to a minimum.

As to the relative merits of ball or roller bearings, opinions differ greatly. Personally, I consider ball bearings, at the present time, superior to roller bearings for electric elevator machines. My reasons for this are based upon considerable investigation which has convinced me that ball bearings can be successfully and practically produced of sufficient capacity to withstand the service imposed. Further than this, ball bearings possess the inherent advantage of being able to run slightly out of alignment without causing destructive strains or excessive friction. With roller bearings slightly out of alignment, even though this be not sufficient to set up destructive strains, the friction will be increased very materially. As a matter of fact, actual tests

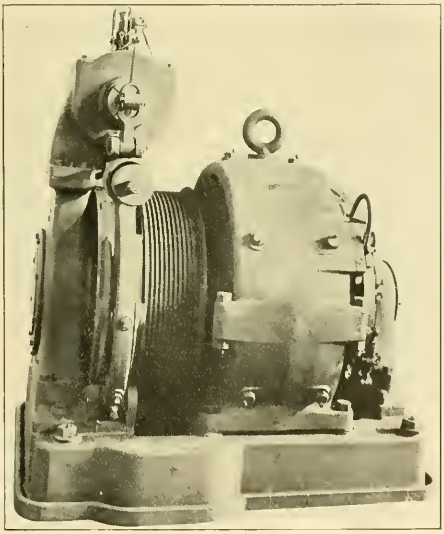


Fig. 8 A Traction Machine of the 1:1 Type fitted with Ball Bearings

have shown that friction induced in this manner can readily be in excess of the friction in a plain bearing. Furthermore, ball bearings are capable of resisting a certain amount of end thrust; quite sufficient, in the case of these traction machines, to take care of the "float" of the armature, partly due to magnetic action, and added to by the action of the hoisting ropes. Roller bearings will permit of no end thrust at all, and therefore when they are used, additional means must be provided to take care of this.

The introduction of ball bearings in connection with elevator machinery was something of an innovation, and entailed the use of bearings of considerable size and strength. At the start, the ball bearing manufacturers apparently and unfortunately did not fully appreciate the special features of design that were required, with the result that some of the earlier bearings of this type were not as suitable as they might have been, or are to-day. However, even taking this fact into consideration, there have been, in proportion to the large number used, very few that have proved unequal to the duty imposed upon them. It is pleasing here to record that while at the start it was supposed that the foreign-made ball bearing represented the highest state of development, to-day the American product has proved itself by far the best that can be obtained.

The total losses in ball bearings may be considered due to three distinct causes; namely, rolling friction, sliding friction

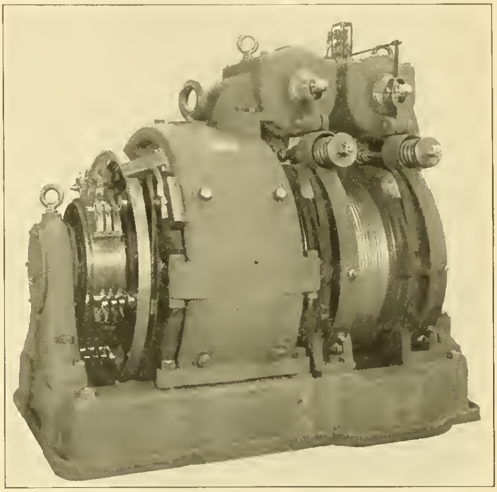


Fig. 9 A Safe-Lift Traction Machine fitted with Ball Bearings

and losses caused by the lubricant. The rolling friction is that loss due to the slight deformation of the balls and their races; this loss is exceedingly small. The sliding friction occurs between the balls and their cage, and to a slight extent between the balls and the races; this latter is occasioned by the differing velocities at various points of contact between the balls and the races, due to deformation. The sliding friction between the balls and their cage in a radial type of bearing is also very small, and consideration of the sliding friction between balls and races may usually be neglected unless the difference in velocities is considerable, as may be the case in the use of ball bearings with close fitting races, heavily loaded.

Paradoxical though in sound, it should be noted that the principal loss in ball bearings is that caused by the use of a lubricant. This loss, of course, depends upon the viscosity of the lubricant and increases greatly with the speed. It is due partly to the churning of the lubricant and partly to the force necessary to squeeze it out of the path of the balls. The main reason for its use is for protecting the bearings from corrosion. The best protection for slow speed bearings is obtained by the use of a moderately heavy grease which

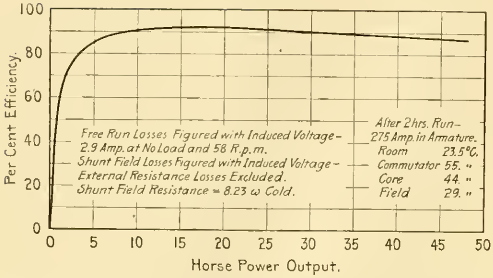



Fig. 10 Efficiency Test of a Traction Motor in the Metropolitan Life Tower

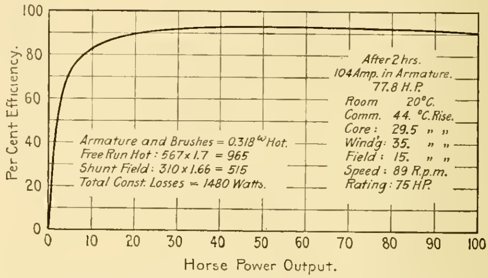



Fig. 11 Efficiency Test of a Traction Motor at the 181st St. Subway Station, New York

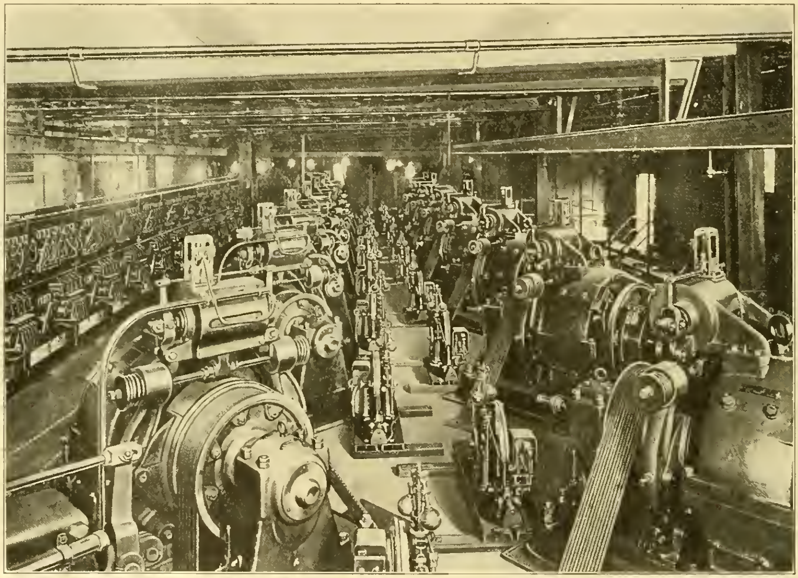


Fig. 12 Typical Overhead Installation of Traction Electric Elevator Machines with Plain Babbitted Bearings

will not flow. Protection from corrosion is important since a speck of rust may soon ruin a bearing. The lubricating properties also reduce wear.

*Method of Control.* Figs. 14 and 15 show controllers used in connection with 1:1 and 2:1 traction elevators and Fig. 16, an installation of a large group of controllers. The speed variation necessary in connection with high speed traction elevators is obtained, partly by field regulation and partly by series and by-pass resistance in the armature circuit. The field regulation is usually capable of reducing full speed down to a speed from 60 to 40 per cent of full speed; further slow-down is obtained by resistance control.

The combination of the two methods mentioned is necessary for obtaining sufficiently slow car speed (about 90 ft. per min.). This slow speed is required for making accurate stops both at intermediate and terminal landings, and also in order to make a very short travel, or to "inch" up or down, to the landing. The exceedingly slow speed automatically obtained when approaching terminal landings is necessary not only to secure accuracy of stops with varying loads, but to provide a fundamental safety feature. It may be mentioned that anti-friction bearings not only materially aid in obtaining smoothness of operation but greatly facilitate the "inching" up to the floor landings.

As a matter of fact, the 1:1 electric traction machine with ball bearings, has practically the smoothness of motion when running, starting and stopping, so much appreciated in hydraulic elevators; yet it comes to a positive stop without the objectionable oscillation and subsequent creeping, inherent in hydraulic elevators.

In connection with the regular operating features of the control apparatus, there are also a number of other features introduced for the purpose of safety. Some of these may be merely mentioned without going into too great detail:

*a* Automatic return of car switch to "off" position.

*b* Automatic stopping switch on car for automatic stopping at terminal landings.

*c* Final cut-out limit switches in hatchway operating independently of the automatic stopping switch.

*d* Switches operated by centrifugal governor automatically stopping the elevator in case of overspeed; the first switch cuts the power off from the machine and applies the dynamic brake effect to the armature, and applies the mechanical brake to the brake pulley; the second switch applies the light retarding force to the car safety referred to later under the subject of electro-mechanical safety.

*e* The safety switch in the car under the control of the operator also performs the same function as the two switches operated by the governor.

*f* Regulation of shunt field by centrifugal governor to maintain constant full speed with variable loads.

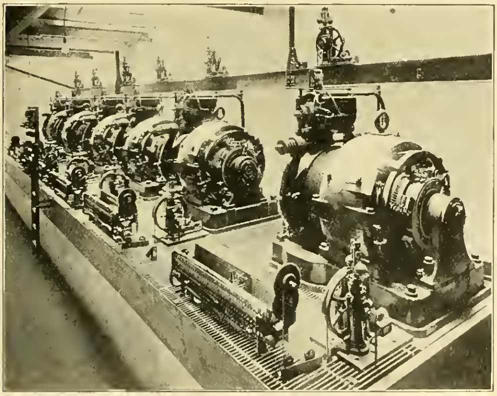


Fig. 13 An Installation of Ball-Bearing Traction Machines

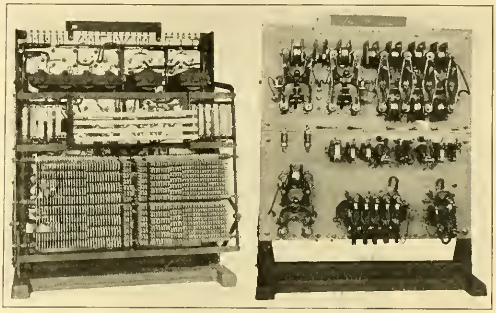
*g* Oil buffers as previously mentioned, capable of independently stopping the fully loaded car when descending at 50 per cent excess speed without discomfort to the passengers.

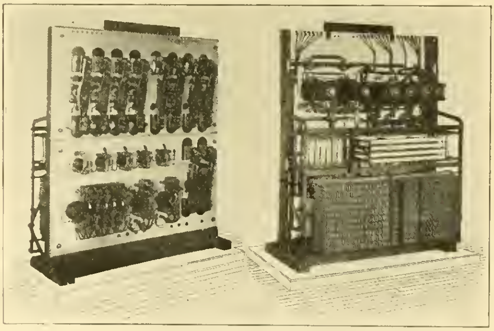
*h* For high rise elevators the use of a mechanical retarding and latching device.

Fig. 17 shows the switch located on the car to effect the automatic stop at terminal landings. This switch is provided with a lever actuated by two cams in the hatchway, one at the upper landing and one at the lower.

*Loads and Speeds.*—Gearless traction machines, utilizing 1 : 1 or 2 : 1 roping, have been built for loads varying from 2000 lb. up to 11,000 lb. at car speeds from 350 up to 700 ft. per min. Of these duties the most generally used for the modern high office building, utilizing 1 : 1 roping, is about 2500 lb. at a speed of 600 or 700 ft. per min., although in many instances, a speed of 500 to 550 ft. per min. is found suitable.

The speed of the high rise elevators in the Woolworth Building is 700 ft. per min., which is at present the highest elevator speed permissible in New York City. In the new Equitable Building in New York, certain of the elevators are arranged to run a portion of their travel on express service at a speed of 650 ft. per min. and the rest of their travel on local service at 550 ft. per min. The change in car speed is automatically accomplished at the point in the hatchway where the character of the service changes. The point at which this change in speed occurs can readily be altered at any time to suit the requirements of the building. The owners of this building considered that a change in speed as just described would be advantageous, and no doubt this will prove to be the case. Reference to the curves in Fig. 18 will make the fact apparent that a reduction in speed from that of the express run, is desirable when the elevator is running





Figs. 14–15 Typical Controllers used with Traction Electric Elevator Machines

in local service. The advantage is found in a reduction of power consumption without an appreciable loss of service time.

The curves in Fig. 18 were produced from tests of the elevators installed in the Metropolitan Life Tower. They show the relation between time and speed, both for express runs and for stopping at every floor; ascending and descending with full load. It will be noted that the maximum speed attained when stopping at every floor is only about 70 per cent of the full speed attained during express run. This is, however, a rather extreme case as the car was very heavy, the ropes were long and consequently the masses to be accelerated were unusually great.

For more moderate speeds and heavier loads, a 2 : 1 roping of car and counterweight is utilized (shown diagrammatically in Fig. 19), which retains the safety features and general characteristics of the 1 : 1 equipments. For moderately high

buildings, this 2 : 1 roping is suitable for a car speed not in excess of 450 ft. per min.

*Geared Machines.* The traction principle is also applicable to elevator machines employing moderately high speed motors with some form of gearing between the motor and driving sheave. Machines of the geared type are most suitable when lower speeds are involved or where the service conditions are not so severe. Under these conditions the power consumed will be comparatively small on account of the lesser mileage, and hence the more expensive gearless machine with its reduced power consumption may not be necessary.

As far as smoothness of operation is concerned, a geared machine can obviously never equal that of a gearless, on account of the fact that it is practically an impossibility to manufacture any kind of gears which are perfect, and mount the same in absolute alignment. Furthermore, if this condition of perfection could be established, it could not be maintained in service, on account of the inevitable wear that would take place.

Two types of geared machines have been developed, one employing worm gear and the other herring-bone gear reduction (see Figs. 20 and 21). Of these two, the worm geared is suitable for slow and more moderate speeds, and is used extensively for this purpose. The machine with herring-bone gear reduction is of course not suitable for slow car speeds on account of the difficulty in obtaining sufficient speed reduction. Undoubtedly, it is somewhat more efficient than worm gearing, and has been used with some success in connection with quite high speed elevators. The fact that the herring-bone geared machine has been used for these high speeds should not be understood as indicating that it is equal to the gearless machine, with which it cannot compare as to operating features and power consumption.

Of the two kinds of gears mentioned, the worm gear has inherently less tendency to vibrate than the herring-bone gear. On the other hand, the herring-bone gear is generally more efficient than the worm gear.

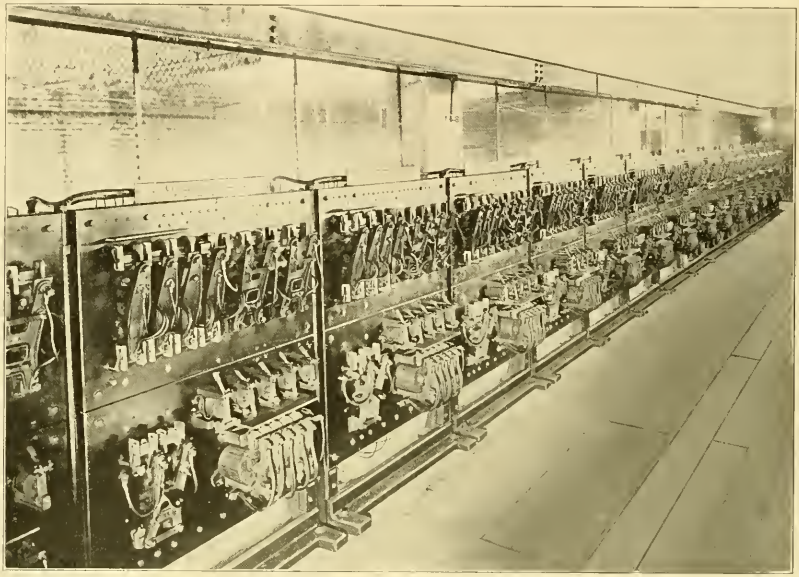


FIG. 16 A LARGE GROUP OF TRACTION ELEVATOR MACHINE CONTROLLERS IN AN OVERHEAD INSTALLATION

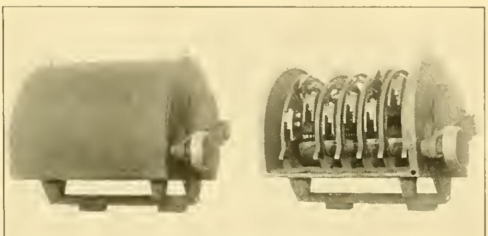


FIG. 17 AUTOMATIC STOPPING SWITCH LOCATED ON CAR

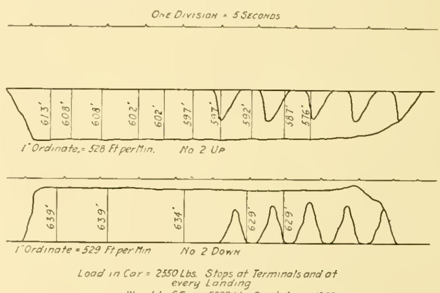



FIG. 18 SPEED CURVE OF HIGH-RISE ELEVATOR IN THE METROPOLITAN LIFE BUILDING TOWER

A number of tests of herring-bone gears (Fig. 22) cut by Falk, Fawcus and Otis, have been made, and Fig. 23 shows the results of a series of tests of one particular gear. The difference in efficiency at various speeds is noticeable. This gear has 213 teeth and the pinion 23 teeth, resulting in a gear ratio of 9.27:1. A motor speed of 425 r.p.m. gave a car speed of 500 ft. per min. There was quite a difference in the efficiency of the gear at different speeds. The losses included in figuring the efficiency comprised the bearing losses and losses due to the churning of the oil. The difference in the efficiencies at different speeds is due principally to this churning of the oil, the loss from this source being about 1.5 h.p. at a speed corresponding to a car speed of 500 ft. per min. This appears to be quite a considerable loss, when considering that it is a loss due to the lubricant.

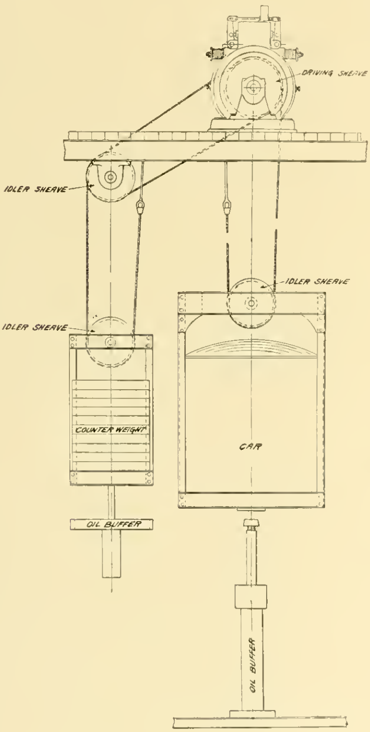



Fig. 19 2:1 Roping of a Gearless Traction Elevator

If the oil is taken out of the gear case and an amount of oil sprayed on sufficient only to prevent cutting, these efficiencies are somewhat increased, particularly for high speed. Under these conditions, the efficiency is practically the same at different speeds; in other words, the efficiency goes quite a little over 90 per cent.

A great number of tests were made also of worm gears with from 1 up to 12 threads on the worm, and with a large variation in the number of teeth in the worm gears. With a 12-thread worm and a 108 tooth worm gear, giving a speed reduction of 9:1 or about the same as that of the herring-bone gear, the efficiency was only from 2 to 3 per cent lower, indicating that for high speeds, with comparatively low ratio of reduction, the worm gear is quite efficient. The worm gears with high pitch worms are by no means as inefficient

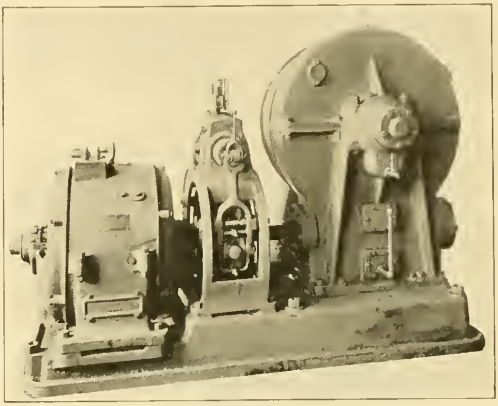


Fig. 20 A Geared Traction Electric Machine using Worm Gearing

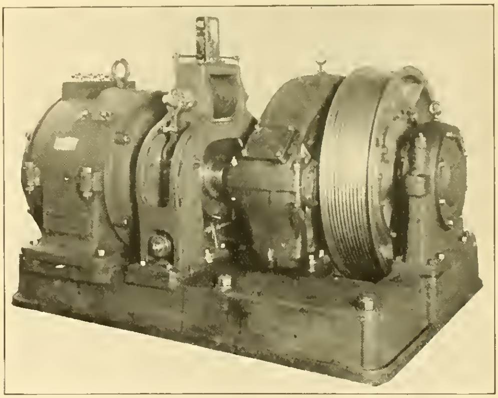


Fig. 21 A Geared Traction Electric Machine with Herring-bone Gearing

as generally thought. The effect of the oil in this case was practically the same as already mentioned in connection with the herring-bone gear; in other words, at a speed corresponding to 500 ft. per min. car speed, the oil losses were about 1.5 h.p.

*Power Consumption.* Considerations of power consumption in the machine may be divided into three parts relating respectively to motor efficiency, gear efficiency and inertia:

*First.* The maximum efficiency of the high speed motor used in connection with the geared machine may occasionally be as high as that of motors used with the gearless, but the efficiency at lighter loads, which is the normal service condition, is lower; hence the high speed motor is at a disadvantage. An equal amount of field regulation may be applied to both high and low speed types of motors.

*Second.* High speed motor machines may be considered to have, under the best conditions, a gear loss of about 10 per cent, whereas this loss is entirely eliminated in the gearless machine.

*Third.* Although kinetic energy is the most important factor in power consumption, it has in the past been apparently very little considered. The reason for this is due probably to difficulty in readily determining its amount, in a rather complex elevator machine. A method which is very simple and at the same time quite accurate, will therefore be described.

One of the methods for determining the kinetic energy consists in determining the amount of the inertia of the rotating parts of the elevator by, for instance, the pendulum method, and in ascertaining the mass of the other parts, having straight line motion, by weighing them. This method has a disadvantage in that it cannot be applied to a complete elevator installation. In addition, it is difficult and tedious of execution.

A simpler and more accurate method, not affected by the variation of the coefficient of friction and the windage losses at different speeds, may be explained as follows:

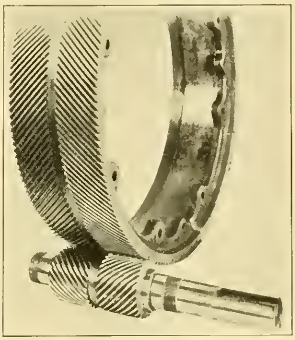


FIG. 22 HERRING-BONE GEAR AND PINION

The kinetic energy of a complete elevator system is the sum of the kinetic energies of each of its constituent parts. In general, these parts run at different speeds, but by reducing all forces and masses to a certain speed, say the speed of the elevator car, the problem can be treated as if involving a single body. If the speed in feet per second of this body equals $v_1$ when the time equals zero, the kinetic energy ($E = 1/2\ m\ v_1^2$) may be expressed by the equation:

$$E = \int_0^T pvdt$$

in which $v$ = the speed at the end of $t$ seconds, $p$ = the retarding force in pounds at the time $t$, and $T$ = the time in seconds in which the body comes to rest. In this equation $pv$ is the work in foot pounds per second done by the retarding force.

If the rate of work is expressed in watts, we have

$$E = 0.7373 \int_0^T wdt$$

in which $w$ represents the retarding watts at the speed $v$. It will be noted that the quantity under the integral sign is the area comprised between the retarding watt-time curve and the axis of time.

To obtain the data for this curve, we may assume the object to be the determination of the kinetic energy of a complete elevator installation at the time when the elevator car has attained the speed $v_1$. Preferably, the load on the car side of the driving sheave should equal and balance that on the counterweight side. This can be accurately effected, without weighing, by merely taking watt-meter readings for up and down travel at equal speeds, adjusting the load in the car until the up and down readings are equal, indicating that both sides are balanced.

The car is then run at the speed $v$, when the armature current (but not the field current) is interrupted, so that the system may come to rest retarded by the mechanical friction, windage and core losses of the motor. The indicated work in watts due to friction, windage and core losses is then equal to the retarding watts $w$ in the above equation. The speed and time are also observed and a graph of the speed-time curve is drawn.

Next, the motor is connected to the line, the elevator run at different speeds, and the watts input observed for each speed. If the $I^2R$ losses represent the losses in the armature winding of a direct current motor and $W$, the observed watts required to run the elevator at the speed $v$, evidently then $W—I^2R$ gives the watts necessary to overcome the friction, windage and core losses. Consequently, $W—I^2R$ at the speed $v$, is equal to the retarding watts $w$ at that speed.

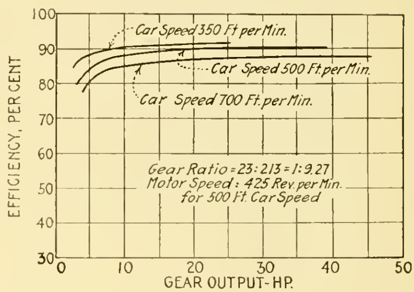



FIG. 23 RESULTS OF EFFICIENCY TEST OF A HERRING-BONE GEAR

The second series of observations, therefore, provide the data for the graph of the retarding watts-speed curve. Having thus obtained the graphs of the speed-time curve and of the retarding watt-speed curve, it is a simple matter to construct the retarding watt-time curve. The quantity $W$ may then be obtained by means of a planimeter and, with the aid of the above equation, the kinetic energy at speed $v_1$ may readily be calculated.

The retarding watt-time curve is so nearly a parabola that only an inappreciable error results from considering the curve as such. Instead of obtaining the area representing $wdt$ by means of a planimeter, it is sufficient to employ the equation of a parabola, whereby this area is found to be one-third of the product $w_1T$; $w$ being equal to $w_1$ when the speed $v = v_1$ which occurs when $t = o$.

When, therefore, extreme accuracy in the determination of the kinetic energy is not required, it is sufficient to obtain merely two observations or readings; one being the time $T$ in seconds in which the elevator comes to rest after the armature current is interrupted at the speed $v_1$, and the second

being $w_1$ in watts, which is equal to the watt-input $W$ required to run the elevator at the speed $v_1$ minus the $I^2R$ losses.

If it is required to determine the kinetic energy of the hoisting machine only, the car and counterweight may be blocked, and the tests made as before. By removing from the machine part after part, and making tests after each removal, the kinetic energy of each of the various moving parts may be obtained.

It will be noted that the method outlined above refers to direct current machines; however, with necessary modifications in regard to the determination of $w$, the retarding watts, this method may be applied to alternating current machines also.

An idea of the relatively high cost of operation of electric elevators, utilizing high speed motors with gears, may be gained by means of the following example: Assume a weight of 1 lb. revolving at a radius of 9 in. at 800 r.p.m. (which is the speed usual with motors for worm gear machines). The kinetic energy to be imparted to this weight each time it is started from rest and brought to full speed will then be 61.3 ft.-lb.

If the elevator starts on an average of 4500 times per day and runs three hundred days per year, the cost of the energy absorbed for acceleration, at 4 cents per kw-hr. would amount to $1.25 per lb. per year. If, instead of one lb., the weight were 219 lb. (which is the effective equivalent weight of a particular herring-bone gear machine), the cost would be $273.00 per year.

Of course, part of the kinetic energy required for starting is returned at the time of stopping, but on the other hand the starting efficiency is low, since a large amount of the power is lost in the starting resistance and some in the motor. The loss in the starting resistance and motor is certainly larger than the energy recovered at the stop, and hence the cost per year for accelerating and retarding 219 lb. of weight, under the above conditions, would amount to more than $273.00.

In ordinary passenger service the load taken up and distributed to the various floors of the building is practically the same as the load brought down to the starting point, therefore, the electric power consumed is not primarily power required for the transportation of passengers, but is the work required to overcome friction and to supply the kinetic energy for each start, less the amount that is recovered at the stop. The friction losses are by far the smaller of the two. Therefore, a comparison of the kinetic energies of two elevators, for the same service and with the same method of control, gives a good indication of what their relative power consumption and rapidity of acceleration will be in actual service.

In the following tabulation are given the kinetic energies of two traction machines, one with herring-bone gear and the other gearless, both built for a car speed of 600 ft. per min., and for the same load. The herring-bone gear machine had a motor running at 505 r.p.m., a pinion with 23 teeth, gear with 213 teeth, and driving sheave 42 in. in diameter. The gearless machine had a motor running at 63.6 r.p.m. and a 36 in. driving sheave.

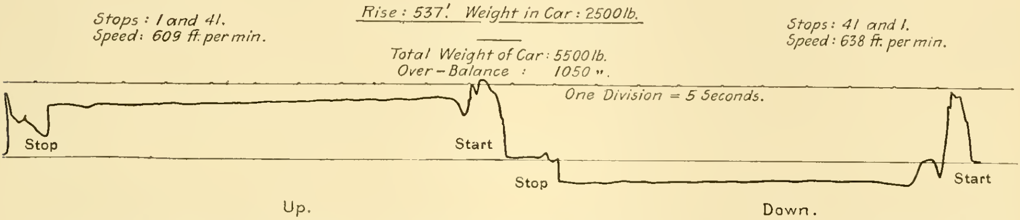



Fig. 24 Power Consumption Curves of a Traction Elevator Machine in the Metropolitan Life Building Tower

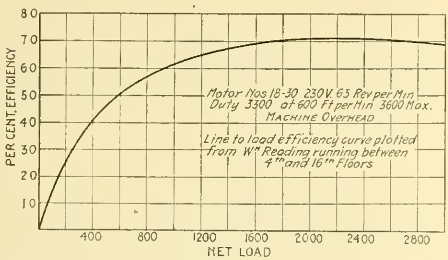



Fig. 25 Efficiency of Complete Gearless Traction Elevator Installation—New York Telephone Building

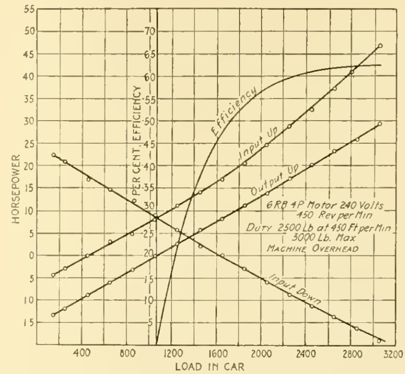



Fig. 26 Efficiency of Complete Herring-bone Gear Traction Elevator Installation—Yale Club Building

| | | *Kinetic energy in ft.-lb.* |
|---|---|---|
| Herring-bone gear machine | motor armature | 7,420 |
| | brake pulley | 2,920 |
| | driving sheave | 1,000 |
| | herring-bone gear | 2,060 |
| | Total | 13,400 |
| Gearless machine | Armature, brake pulley, driving sheave | Total 2,450 |

It will be noted that the kinetic energy per start of the herring-bone machine would be about 5.5 times that of the 1:1 gearless machine. Consequently, if the cost of power for accelerating and retarding the 13,400 ft.-lb. of the former amounted to \$273.00 per year, the cost for the gearless machine would be but $\frac{\$273}{5.5}$ or \$50.00.

It may not be at once apparent why the high speed motor with armature of much smaller dimensions, although running

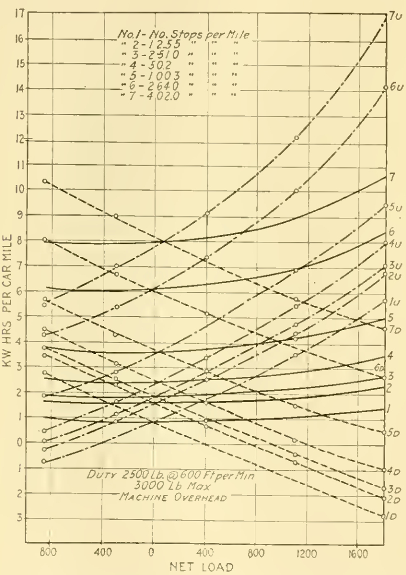



FIG. 27 POWER CONSUMPTION TEST OF A TRACTION ELEVATOR MACHINE IN THE ADAMS EXPRESS CO. BUILDING

at high speed, should have such high kinetic energy, compared with that of a slow speed armature of much heavier weight and larger dimensions. A simple example may be given illustrating this fact.

Take a motor of certain construction and field strength, and assume that on a 220 volt circuit it will develop 10 h.p. and run at 100 r.p.m. On a 440 volt circuit, this same motor with equal armature current and with shunt field arranged to maintain the same field strength, will develop 20 h.p. and run at 200 r.p.m. That is, the voltage being doubled, the horsepower and speed will be doubled; and, the kinetic energy, varying as the square of the speed, will be quadrupled. If then, we assume the kinetic energy in the first case to be 500 ft.-lb. that in the latter case will be 2000 ft.-lb., and the kinetic energy per horsepower of the motor running at 100 r.p.m. will be $\frac{500}{10}$ or 50 ft.-lb., and that of the motor running at 200 r.p.m. will be $\frac{2000}{20}$ or 100 ft.-lb. In other words, in this example, doubling the speed will double the kinetic energy per horsepower output.

As already indicated, the kinetic energy of a complete herring-bone gear machine was approximately 5.5 times the kinetic energy of the gearless. This increase is not directly proportional to the speeds of their respective motors because the ratio between the kinetic energies of the driving sheave, brake and gear coupled to the motors, is considerably less than proportionate to the motor speeds. If, however, the

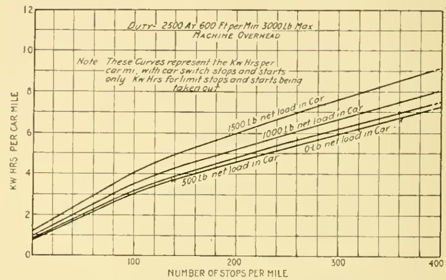



FIG. 28 AVERAGE POWER CONSUMPTION FOR VARIOUS LOADS AND NUMBERS OF STARTS—EXPRESS SERVICE—ADAMS EXPRESS BUILDING

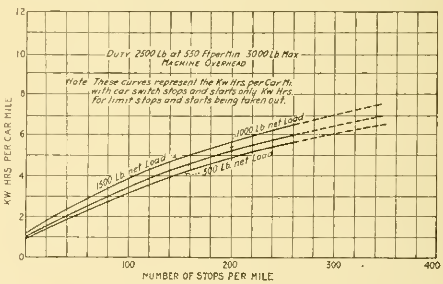



FIG. 29 AVERAGE POWER CONSUMPTION FOR VARIOUS LOADS AND NUMBERS OF STARTS—LOCAL SERVICE—ADAMS EXPRESS BUILDING

armatures only are considered, the fact would be disclosed that in this case the kinetic energy is more than proportional to the speed because, on account of the gear losses, the geared machine requires a motor of greater capacity than does the gearless machine.

At this point, it may be interesting to observe the efficiencies and power consumption of some actual installations. The curves in Fig. 24 show recording wattmeter readings taken in the Metropolitan Life Tower of an elevator carrying a load of 2500 lb. up and down. The upper curve indicates the watts taken when lifting the load and the lower curve the watts required for starting, and the watts generated back into the line, when the load is descending.

The curve in Fig. 25 shows the efficiency of a complete installation of a gearless traction elevator in the New York Telephone building, at Walker and Lispenard Sts., New York. It may be noted that the maximum efficiency from line to load, allowing for all losses, is over 71 per cent. The curve in Fig. 26 shows the efficiency of a complete elevator installation of a herring-bone gear machine in the new Yale Club building in New York City. It may be noted that the maximum efficiency from line to load is about 62 per cent.

The curves in Fig. 27 show the results of recording wattmeter readings taken at the Adams Express Company's building, New York City. The loads indicated are net loads; that is, loads representing the unbalanced difference between weights on the car side and weights on the counterweight side of the driving sheave; and the ordinate at zero indicates the balanced condition of these weights. The broken curves, ascending from left to right, represent power consumption while lifting unbalanced weights. The broken curves, descending from left to right, represent power consumption while lowering unbalanced weights. The full line curves, drawn between the former, represent the average power consumption required for lifting and lowering weights. Curves are shown for various numbers of stops per car mile, ranging from no stops to 402.

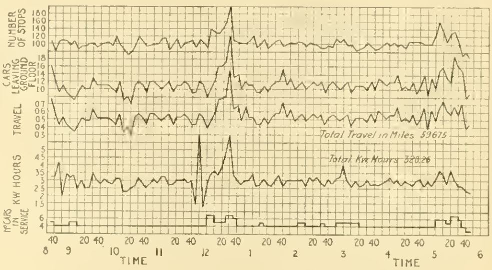



FIG. 33 LOCAL SERVICE

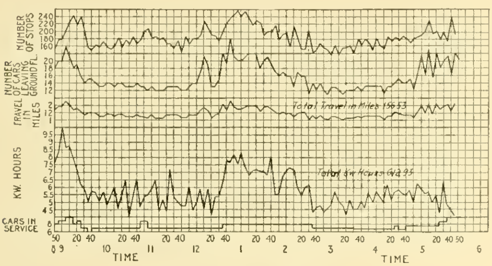



FIG. 30 EXPRESS SERVICE

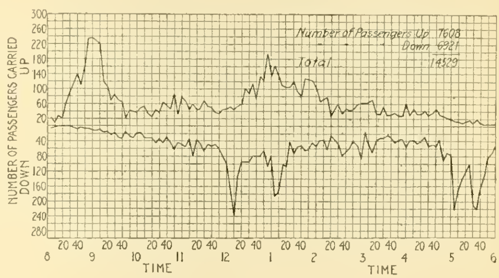



FIG. 34 EXPRESS SERVICE


FIG. 31 LOCAL SERVICE

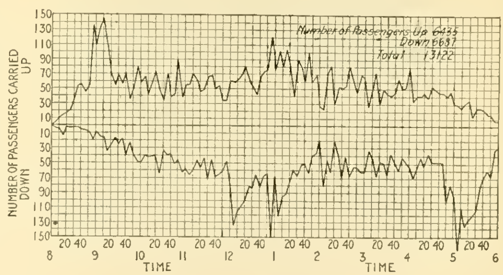



FIG. 35 LOCAL SERVICE

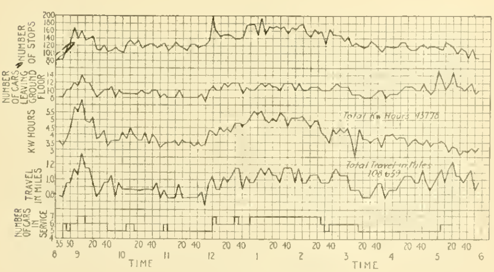



FIG. 32 EXPRESS SERVICE

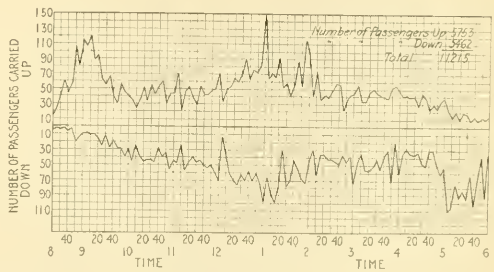



FIG. 36 EXPRESS SERVICE

CHARTS OF ELEVATOR SERVICE AT THE HUDSON TERMINAL BUILDINGS

The average amounts of power consumption, for various loads and numbers of starts, are plotted in curves shown in Figs. 28 and 29. These curves indicate the increase in power consumption occasioned by an increase in number of starts while transporting various loads, Fig. 28 representing express and Fig. 29 local service. By referring to curve 2 in Fig. 28, it may be noted, that with a net or unbalanced load on the car side of the driving sheave of 500 lb., the power consumption would be 0.8 kw. per car mile when no stops whatever are made, and about 3.2 kw. when there are 100 stops. The net load of 500 lb. represents a load in car amounting to 1500 lb. partly balanced by a 1000 lb. counterweight. By comparing the curves one with another, it may be noted that the power consumption increases with the number of starts to a greater extent than with a corresponding increase in net load. Comparison between curves in Figs. 28 and 29 will indicate that the power consumption for equal loads and number of starts, is greater for the express service than for the local service, due to higher speed and greater masses.

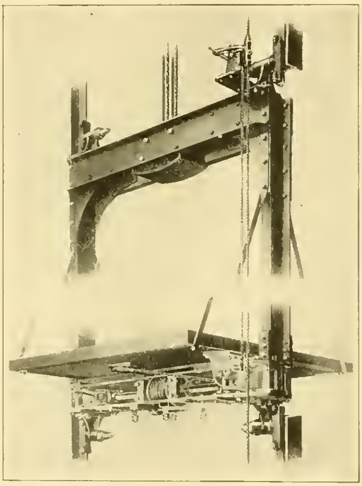


FIG. 37 A TYPICAL APPLICATION OF THE WEDGE-CLAMP SAFETY

A number of observations have been made of the actual service conditions encountered in different buildings. Some of the most interesting are those of the Hudson Terminal Building in New York City, where the service conditions are usually severe and varied. The curves in Figs. 30 to 33 record these conditions, indicating the number of cars in service, the power consumption in kilowatt hours, the miles traveled, the number of cars leaving the ground floor, the number of stops, etc., during hours from 8 a.m. to nearly 6 p.m. Both express and local service for certain groups of elevators at the 30 Church St. and the 50 Church St. buildings are represented.

The curves in Figs. 34 to 36 record the movement of passengers during different hours of the day; the upper curves showing the number of passengers carried up and the lower curves, the number carried down. These curves well illustrate the tremendous inrush and exodus of passengers during short periods of time, morning, noon and evening; as well as the normal traffic between times.

The curves in Fig. 36 illustrate the most severe "rush-hour" service encountered. It may be observed that at about 8.30 in the morning, there is a tremendous inrush for about twenty minutes, which tapers off to a slight rush later on; around ten o'clock, or half-way between the rush hours, there is about the same amount of service in both directions. Then just at twelve o'clock, sharp, there is a tremendous rush outward, which is all over in ten minutes. In other words, all these passengers have had to be taken out of the building in ten minutes, the same number being handled, from 12.20 on, during the inrush which, however, lasts for about twenty minutes. Then, during the afternoon, may be noted the continuation of traffic up and down, in about equal amounts. The promptness with which the people leave the building at night may be observed by referring to the curve in Fig. 36.

These charts show service conditions, indicating what tremendous variations of traffic are encountered in elevator service. In order to prevent congestion in a building the elevators must be capable of taking care of at least half, or say about two-thirds, of all the people in a building during practically only ten minutes. They indicate further how necessary it is to be able to maintain high speeds during rush hours. At such times, when the elevators have to carry all the people up, speed is an important factor. In this respect, the electric traction elevator has the advantage over the hydraulic elevator, in that it is capable of maintaining constant speed independently of the load, whereas the hydraulic elevator varies its speed with variations in load. In other words, during the time of maximum service, with fully loaded car, the hydraulic elevator runs at its minimum speed, whereas with light loads, when speed is not important, the speed is maximum. Undoubtedly, this indicates one of the principal reasons why the electric has gradually, and now almost entirely, supplanted the hydraulic elevator.

*Electro-Mechanical Elevator Safety.* In conclusion, mention may be made of various elevator car safeties, with particular reference to a new safety that has lately been put on the market. The essential requirement of an elevator car safety is to stop and hold an elevator car under all conditions of load and speed, whether the hoisting ropes are intact or parted. Fig. 37 illustrates the safety device usually employed until a comparatively short time ago; and which, even at the present time, is still installed. It is the standard so-called wedge clamp safety, which clamps the rails for retarding and holding the elevator car in case of overspeed or free fall.

The present practice utilizes the same principle of application whether the safety is actuated under conditions of excessive speed with hoisting ropes intact or during free falling. A very strong retarding force is required to stop a free falling car, but this strong retarding force if applied with ropes intact is excessive and will give an unpleasant shock to the passengers.

This is obvious when an actual installation is analyzed. Th car, with all attachments, of a modern high rise elevator, weighs about 6500 lb., the maximum load is usually 3000 lb. and the compensating ropes weigh about 2500 lb.; the total load to be stopped by the safety with the ropes parted would therefore be 12,000 lb. To insure the stopping of a car, at

least 50 per cent excess force should be provided, bringing the total retarding force required, up to a minimum of 18,000 lb. Were a major portion of this retarding force applied with the ropes intact, the car would be stopped too abruptly. This would be accentuated with a light load, particularly as the machine brake and strong dynamic action of the motor assist the retarding force of the safety.

For the above mentioned reasons, it is essential, therefore, that the safety should apply a *strong retarding* force in case of a free falling car with ropes parted, and a *light retarding* force in case of overspeed with ropes intact. The principal safety features which should be incorporated in an elevator safety for high speed elevators are as follows:

*a* The safety should be so arranged that the application of a predetermined and definite *light retarding* force will stop the car and net load without shock in case of overspeed with hoisting ropes intact.

*b* The safety device should be so arranged that the application of a predetermined and definite *strong retarding* force will gradually bring the car and maximum load to rest in case of a free falling car.

*c* The *light retarding* force should be immediately applied, preferably by means of a centrifugal governor, in case the car should attain excessive speed in either direction.

*d* It should be possible to apply immediately the *light retarding* force from within the car, when desired.

*e* The *light retarding* force should be applied automatically in case of overrun at the upper or lower terminals, and yet be so arranged as not to interfere with the starting of the car in the opposite direction.

*f* The *strong retarding* force should start to apply the instant the hoisting ropes part, independently of the speed of car and counterweight.

*g* A tripping governor should not be necessary to apply the *strong retarding* force, except on safe lift machines.

*h* In the case of safelift machines, a *strong retarding* force should be automatically applied independently of the parting of the hoisting ropes, at a definite speed which should be higher than the speed at which the *light retarding force* is applied.

*i* The releasing carrier, even when improperly adjusted, should not prevent the application of a *strong retarding* force to the car in case the ropes part.

*j* The principal actuating parts of the safety should be made to move automatically at frequent intervals, in order to prevent them from clogging up or corroding together; this motion of the actuating parts need be only very small, to give the desired results, but some motion is necessary to secure dependable action of the safety.

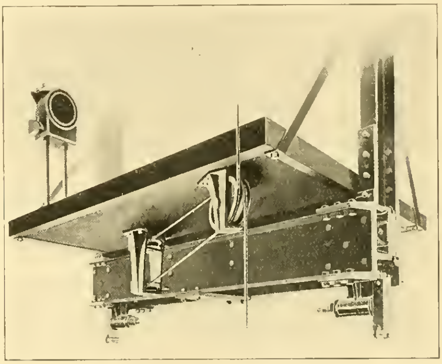
Figs. 38 and 39 show the general features of an electro-mechanical elevator car safety which embodies all of the above described requirements. The *light retarding* force is obtained by means of a helical steel spring forcing the wedges between the rollers of the safety jaws. When the car is in service this spring is held under compression by means of an electro-magnet. The instant the current in this magnet is interrupted, either by the centrifugal governor, safety switch in car or limit switches in the hatchway operated by the car or counterweight, the *light retarding* force is applied.

The *strong retarding* force is obtained by revolving the safety drum, thereby actuating the right and left hand screw, which in turn moves the wedges and forces the jaws against the guide rails. The *strong retarding* force is definitely determined by the number of turns around the safety drum, which vary in number according to the maximum load and the amount of the safety rope tension weight.

The releasing carrier is placed on the counterweight and will therefore apply the *strong retarding* force of the car safety, even though the releasing carrier fails to release, due to faulty adjustment. The *strong retarding* force only is applied to the counterweight safety.

Whenever the current is cut off from the elevator, the electrical parts of the safety are operated, thereby applying the *light retarding* force. The mechanical actuating parts of the safety effecting the *strong retarding* force are continually kept in slight motion when the elevator is in operation, due to the different stretching of the hoist and governor ropes. It is possible to remove all parts without disturbing the car platform, enclosure or car frame, thereby assuring easy access for inspection. In case of safelift elevators, a *strong retarding* force as described in paragraph *h* is applied by means of a parallel jaw double acting governor.

An electro-mechanical safety device such as just described has been designed and built by the Otis Elevator Company and subjected to a long series of experimental tests, the results obtained being remarkably successful. Some forty-nine elevators in the new Equitable Building have been equipped with these safeties and the consulting engineers, the builders and the New York Building Department have thoroughly and exhaustively tested them with entire and complete satisfaction to all concerned.



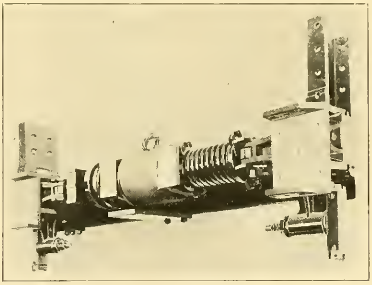


Fig. 38 Detail Views of an Electro-Mechanical Safety as Applied to a Car

## DISCUSSION

Reginald P. Bolton called attention to the remarkable development in the electric elevator, which now stands far and away at the head of all other types, and suggested that this meeting may be adequately described as the funeral service of the plunger elevator. He stated that there are 4,000 of the old hydraulic elevators still in service in New York, and referred to a scheme which Mr. Charles R. Pratt has developed for utilizing certain details of the hydraulic equipment in connection with electrical machines, instead of discarding the old hydraulic equipment entirely.

Mr. Bolton stated that the construction of the elevator and the facilities with which it is provided cover only one half of the work which the elevator accomplishes, the other half of the time in which the elevator is in operation being devoted to the operations of loading and unloading passengers; he felt that considerable opportunity remains for improving elevator operation, and referred to such elements as the operator, his position in the car, starting and stopping the car, the control of doors and gates, systems of signaling, and the handling of passengers.

Mr. Bolton also discussed at length the difficult problems of passenger traffic in the elevators of the large New York City buildings, and quoted from his observations as to traffic peculiarities in other cities as well, and their effect upon the elevator service.

Charles R. Pratt called attention to the fact that there are still some 4,000 of the old hydraulic elevators in use in New York City, costing two or three times as much per car mile as the modern electric elevator would cost. They are in all stages of repair, and finally they will wear beyond repair and must go out, but many of them are still good for many years more. In looking into the matter in the last few months he found the problem to be as follows:

To change over to an electric elevator, one has to charge off 10 per cent to depreciation, and if the initial cost runs up, as it does some times, to $4,000, $6,000 or $8,000 in an electric elevator, and if the owner charges off that 10 per cent depreciation, it wipes off the difference in saving in cost per car mile. He stated that it requires only a glance at any graphic recording wattmeter curve of kilowatt-hours per car mile to show that about 75 per cent of the power load on an electric elevator is inertia and not gravity. Modern electric elevators regenerate gravity to a very limited extent and inertia not at all; on the contrary, by the expedience of an armature shunt across the line, they take power to stop the load.

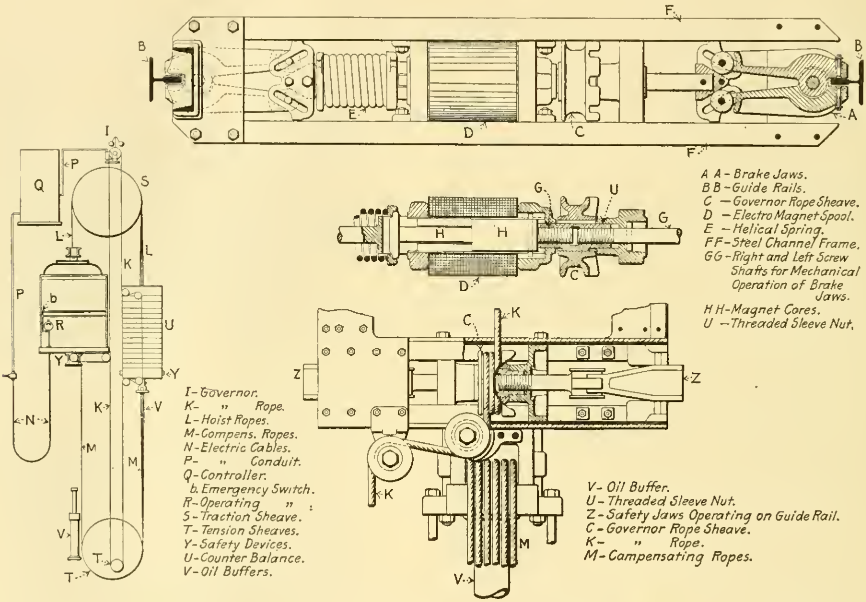



Fig. 39 Constructional Details of the Wedge-Clamp Safety, Electro-Mechanically Operated

Hydraulic transmissions with a variable stroke pump for each elevator, a group of pumps driven by one power unit, offers, Mr. Pratt suggested, a practical regeneration of this inertia energy, but there appears to be no such pump as yet produced to meet all the requirements of this service, although experiments in this have been undertaken. Continuously revolving field or armature electric elevators offer somewhat the same regeneration of energy as the hydraulic transmission, but have not yet been proved to fill the bill.

He pointed out that if the inertia load on electric elevators could be balanced like the piston in a vertical cylinder engine, the kilowatt-hours per car mile could be reduced to about one-fourth the amount now expended. Hydraulic, mechanical, electric and flywheel action offer an inertia balance, but an underbalanced car cuts at the source by reducing

the mass and eliminating all inertia power load on the down trip.

Taking more than twice the maximum net gravity load appears at first thought to be wasted energy, he said, but when it is considered that high-duty hydraulic elevators and the Sprague-Pratt electric elevators, with their mechanical friction losses and no regeneration circuit, take about the same kilowatt-hours per car mile as the average modern electric elevator, the possibilities of high efficiency in underbalanced cars becomes worthy of serious attention.

The advantages, considered in detail, are:

*a* Always driven by gravity on the down trip.

*b* Controlled by armature resistance only, giving all ranges of speed, power circuit up and dynamic circuit down, using no armature shunt across the line to waste power at slow speeds and in stopping.

*c* By use of an automatic potential switch it regenerates efficiently at full speed down, returning a large percentage of the power used on the up trip.

*d* Reduces starting current on up runs by having less mass to accelerate.

*e* No starting or running current used on down trip.

*f* Requires but one field strength for all speeds, reducing size of motor.

If this be applied to a highly efficient modern electric elevator motor, either direct coupled or driven by helical or steep pitch worm gearing, Mr. Pratt stated the results would be interesting. In replacing old hydraulic with new electric elevators, and using an overbalanced car with a back drum counterweight or traction rope drive, all old hydraulic sheaves, overhead beams, counterweights, guides, vertical cylinders, etc., have to be altered, removed and scrapped, new parts substituted, and the entire hoistway brought up to date according to the Building Code laws. Whereas, by use of the underbalanced car, using the entire old hydraulic hoistway equipment undisturbed, even using the vertical cylinder for a continuous safety with a speed regulating valve in the circulating pipe, for water, oil or air, about one-half the total cost of the change over from hydraulic to electric is saved, with practically no interruption to the elevator service. Also a net profit is shown to the owner after he charges off 10 per cent of the initial cost against the amount saved in power and operating expenses.

There are four thousand old hydraulic elevators in New York City and ten times that number outside, waiting for a system that will finance the change to electric drive. Fig. 40 illustrates such a system applied to an old Otis machine. Two more grooves are added to the winding sheave, when the electric machine is located below with a regulating valve placed in the circulating pipe, using either air, oil or water. In the case of excess speed, this balanced piston operates to choke off the circulating pipe, and gives in effect very good safety. The control is very simple. All the magnets are down on the dynamic circuit. When the generated voltage equals or exceeds the line voltage, the potential switch is thrown over, and return is had for what it costs one to hoist.

Andrew M. Coyle took exception to the statement by Mr. Lindquist in reference to the relative efficiences of the direct driven traction machine and the gear driven machine. While no one doubts that for light duty and high speed the direct driven machine is more efficient, there is an immense field in which the geared machine is highly efficient and in which the direct driven machine cannot be used at all. It is, therefore, he stated, not altogether fair to make the comparison based on a car speed of 600 ft. per minute. The geared machine using herring-bone or helical gears is highly efficient for all duties and speeds from 200 to 400 ft. per minute and this service covers the great bulk of elevator installations. He has been connected with the design and installation of several elevator machines using helical gears and has found that the gears were highly efficient and in every way satisfactory.

Mr. Coyle also took exception to the statement that these gears are only slightly more efficient than worm gearing. His reasons were stated as follows:

A worm gear is a special application of the wedge. The load moved is carried forward upon an inclined plane. The load which can be carried upon a single gear is limited. The working surfaces have only line contact, and when the load is enough to force the lubricant from this line, abrasion immediately sets in. To overcome this difficulty, the tandem worm gearing has been designed. By this arrangement the load is divided between two gears and the line of contact thereby increased.

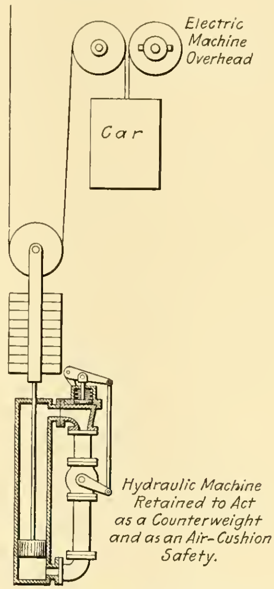



Fig. 40 A Method of Application of Electric Machines to Old Hydraulic Elevators

It is obvious that, within limits, the steeper the incline, the higher the efficiency of the gear. The shorter the distance the load has to slide, the less will be the loss by friction. For this reason gears of high pitch angles give better results.

Worm gears doing heavy or continuous service, must be completely submerged in oil. A certain percentage of the power is expended in churning the oil. The power thus expended is constant for any given gear. When the load is

light, the power expended represents a considerable percentage of the whole work. On the other hand, when loads are light, the surface lubrication is better, and better results are obtained in the thrust bearings.

The *herring-bone* or *helical gear* is the most efficient gearing so far developed for elevator or any other service. These gears when properly cut are practically noiseless. The slight tendency to wear, is at the points of the teeth and tends to throw the load toward the pitch line where sliding friction is least. The helical gear works best when thoroughly lubricated; but it is a mistake to submerge the pinion. The very slight clearance allowed in these gears causes the oil to be confined in the teeth in such manner as to offer great resistance. It is best to use moderately light oil and to give the teeth a chance to drain before coming into mesh.

The efficiency of the worm gear is limited by the fact that the load must slide from five to ten times the distance it is lifted and that it is entirely dependent upon lubrication. In the case of the helical gear the sliding friction is almost negligible; the gears do not wear and cause back lash as is the case with the worm gears and the lines of contact and the strength of the teeth may be made sufficient to take care of any desired load.

An elevator machine using worm gearing, assumes an outline which lends itself readily to installation in buildings and for this reason as well as on account of low cost this type of machine is in some cases to be recommended. In point of efficiency the helical gear is entirely preferable.

Robert Johnson called attention to a condition frequently met with that has not been touched on at all in the paper, namely, the use of alternating-current in connection with elevator operation. The conditions referred to would, he said, hardly apply to an installation of alternating-current machines with regard to reliability or speed, and also as to the application of the brake gradually and slowly. This, he said, was a very important point, and he thought it would be very interesting to know whether alternating current is entirely successful in connection with high speed elevators, particularly in view of the fact that in certain parts of New York City alternating electric current is the only type of current which is available.

M. Wm. Ehrlich, referring to the question of safeties supplied for the protection of elevators, said that while, of course, the standard safety devices usually installed in connection with an elevator become a good precaution, the records of the building departments and also of the different insurance companies, show that the elevator accidents from breakages of ropes or other parts of the apparatus are very small, the more recent statistics showing that about 80 per cent of the deaths in elevator accidents were caused by open or unlocked gates, or negligence in the operation of the gates by the elevator operator. The way to prevent that, he said, was to use a safety or automatic lock, which will necessitate the elevator making a full stop, and so arranged that before leaving the floor, the gate must be positively closed. That, he said, would prevent accidents caused by open doors and gates. A short time ago he had occasion to test an electro-mechanical device of that nature, and found that under actual service conditions the additional time consumed was ¼ second per trip, or only 8 seconds being lost in an average office building of 32 trips an hour.

Referring to the power consumption diagrams presented by the author, he pointed out that all these charts are, from the point of view of service, of paramount importance, and he therefore suggested that the values of stops per car-mile be converted to a more applicable basis as related to buildings; that is, instead of the unit of "stops per mile," these be changed to a unit of so many stops per number of floors.

Where in railroad service all stops are usually predetermined, he said, the first basis is serviceable, but in passenger elevator practice, where the installations occur in buildings of not only different total heights but varying story heights, and where the stops correspond to the demand of the passenger traffic at different parts of the day, it has been found by extensive observation that a unit ratio in which the number of stops are related to ten floors of travel, is the most expedient unit. Exhaustive studies of passenger elevator traffic have established the ratio of 4 to 10, a unit representing four stops in ten floors, as the average travel conditions in office buildings. Thus the observed number of stops in this class of building becomes the measure of proper division of the service when related to the unit of 4:10, which is the most economic point of operation, meaning, of course, current consumption.

Mr. Ehrlich asked that Mr. Lindquist supply the data to enable one to convert the stops per mile into the number of stops in ten floors. This would mean giving the height of elevator travel in feet and the number of floors served by the different cars. To illustrate the importance of the suggested unit, he quoted an example, assuming a case of 264 stops per mile. This would mean a stop every 20 ft. or approximately equal to a landing terminal at every second floor level in a building with 10 ft. floor heights. Then in a ten story building of such proportions this service would be equal to four stops in ten floors, corresponding to the average conditions prevailing in office buildings. Then assuming a 32 story building, with story heights averaging 13 ft. on account of several specially high floors, with the same elevator traffic, or 264 stops per mile, a service would be obtained under this condition of approximately 6:10, or six stops in ten floors. It will be interesting to note on this basis, by examining the charts presented, whether 4:10 is the mean point of current consumption, or whether any other point on the curve represents the most economical operation.

E. W. Marshall spoke of an incident in connection with a certain elevator under test in which the motor had proved not to be heavy enough. The elevator had been tried in the shop and the motor carried the load there, because between the hours of 12 and 1 p.m. every day it was stopped and the motor had a chance to cool off. When the elevator was put into a building and ran across these mountainous peaks which Mr. Lindquist has shown in his charts, it had no opportunity for cooling off and turned out to be unfit for the work which was expected of it.

Alphonse A. Adler asked two questions, one regarding the rate of acceleration of the elevator, and the other concerning the factor of safety on the ropes. According to the author's statement, he said it was about 12, but if the rate of acceleration of the elevator is considered, the stress on the rope, which is due, first, to the ordinary weight of the car, second, to the acceleration of the load, and, third, to bending

stresses in going over the sheaves, will appreciably cut down the factor of safety. There is an additional stress, aside from the bending stress and the force required to accelerate the car, which is not very frequently taken into consideration; that is, in the ordinary type of elevator, when the brakes are put on the rotating mass will be retarded, but the entire energy in the car must be taken up in the actual stress of the rope and he asked what that stress amounts to there.

H. F. Gurney and C. R. Callaway [1] (written). It was but a very few years ago that one's choice was restricted to some form of hydraulic elevator, if the rise was high, requiring a correspondingly high car speed, but recent invention and development have made the electric machine so far superior, particularly with respect to safety, the rapidity with which the car may be handled at landings, the smaller amount of space occupied by the apparatus, and the lower cost of operating, while retaining all of the hydraulic elevator's safety, reliability and smoothness of operation, that it has entirely displaced the latter from its former position of supremacy. While it is generally admitted, however, that the hydraulic elevator has been rightfully superseded by the electric, engineers are by no means agreed as to the best type of electric machine to adopt.

The only practical means of lifting an elevator car electrically appears to be by means of wire ropes, which are either wound up on a grooved drum, or driven by a traction sheave. These may not be smaller in diameter than about 50 times the diameter of the rope used, in order to keep the bending stresses low enough so that the rope will not be rapidly destroyed by breakage of the wires. Space conditions also make it necessary to keep the diameter of the drum large enough to wind up the length of rope required for the rise without making the length or face excessive, and in the case of traction sheaves, a diameter which is too small results in a decrease of tractive effort, with loss of proper control of the car on account of the resultant slippage, which also causes prohibitive wear of the ropes. We find from a consideration of these requirements that the speed of the drum or traction sheave in revolutions per minute for the car speeds used for rises of 150 ft. and upwards will fall approximately within the following limits:

| Car Speed. Ft. per min. | Speed of Drum or Traction Sheave Rev. per min. |
|---|---|
| 300 | 29 to 35 |
| 350 | 34 to 40 |
| 400 | 39 to 46 |
| 500 | 49 to 58 |
| 600 | 59 to 70 |
| 700 | 68 to 81 |

In order to drive the drum or traction sheave at these speeds electrically, two methods may be used: *a* an abnormally slow speed motor may be connected directly to the traction sheave, this arrangement being known as a 1:1 machine; *b* a moderate speed motor may be connected to the sheave through a suitable gear reduction.

We pass over, as unworthy of consideration, the arrangement in which the traction sheave runs at twice the speed required with direct roping, by the use of multiplying sheaves on the car and counterweight, driving these ropes by a motor connected directly to the traction sheave, the combination being known as the 2:1 traction elevator. This method of roping is one which has long been used for slow speed freight work, and in this class of service it is not objectionable, but when applied to high-speed passenger service it becomes a makeshift which ought not to be tolerated. The power losses are greatly increased and the cost of current made correspondingly higher, while the cost of keeping the elevator supplied with ropes is exorbitant. The fact that it is used is, however, an admission that the higher speed motor has advantages over the abnormally slow, 1:1 type. A mechanical brake is needed on the machine to bring the car to a final stop after it has been slowed down as much as possible by the dynamic or electrical braking action of the armature, and as in the 1:1 and 2:1 machines, this must act directly on the traction sheave shaft, the same as the armature, it must be a very powerful one. The wear is severe on account of the heavy pressure with which the shoes must be applied to the pulley, and the adjustments are delicate and frequently required.

The difficulties encountered in designing a motor for an output of from 30 to 40 h.p., at a speed of 50 to 60 r.p.m., are so apparent that it is unnecessary to recite them here, and the engineer's best efforts must inevitably result in a ponderous armature, wound with a large number of turns of wire, which must be of large cross-section if the efficiency is to be anywhere within reason, and an enormous field structure to carry the heavy flux necessary to develop the torque required. It imposes an unreasonable load on the building structure, requires so much space that unless the cars are unusually large it is necessary to install machines of this type on two levels, requires very expensive supports and pent-house construction, with a traveling crane of about 5 tons capacity over them to handle the pieces when taking a machine apart, and results in the machine being out of service for days at a time in case repair is necessary. It has, moreover, the poor commutation resulting from carrying heavy currents through so many armature turns, causing a high reactance voltage, and makes it very difficult to keep the commutator in good condition. A motor of this type will have so much copper on its armature that the internal voltage drop or rise caused by its resistance will result in a wide variation of speed, between the extremes which will be met in service, one of which is lifting a heavy load, when a heavy current will be drawn from the line, and the other, lowering a heavy load, when a heavy current will be generated into the line. The reduction of the speed in the first case, and the increase in the second, will be excessive, and this poor speed regulation is very undesirable in passenger service.

In any high speed elevator, it is necessary to reduce the car speed just before stopping, to a fraction of the normal speed, in order to make it possible for the operator to stop the car accurately at the floor level, and to reach the terminal landings without danger of striking the buffers or overhead work. To accomplish this reduction in speed, there are two possible methods which may be employed: *first*, an increase in the magnetic flux through the armature, and, *second*, a reduction in the voltage across the armature terminals. The former is, of course, recognized by all as the preferable means of affecting a variation in motor speed, and is in general use under all imaginable conditions, but this method cannot be applied to the 1:1 machine to a sufficient extent,

[1] Superintendent, Gurney Elevator Co., New York.

The advocates of this type will admit that it is simply out of the question to make the speed with maximum field strength less than about 45 r.p.m., which, with a traction sheave 33 in. in diameter, will give a car speed of about 390 ft. per min. As this is entirely too high a speed from which to make landings accurately, it becomes necessary to resort to the other method to reduce the speed still further; that is, to get a lower voltage across the brushes by some means. This might possibly be done by using a multiple voltage power supply, but the application of such a system presents so many difficulties, requiring complicated controlling apparatus, with special generators to supply the low voltage, that it has not been attempted.

The accepted scheme is to use resistances, one in series and one in parallel, with the armature, with means under the operator's control for varying them as required by the load in the car and the direction in which it is moving, to reduce the speed as much as may be desired. A single resistance in series with the armature cannot be used, because the counterweight is always made heavier than the empty car by an amount equal to the average load, in order to reduce to a minimum and equalize as far as possible the work done by the motor, which thus acts as a generator and returns power to the line when the car runs up with no load or a light load, or down with a heavy load. At such times the series resistance alone would result in an increase of speed instead of a decrease. In considering the circuits with this arrangement, it must be borne in mind that with any given condition of load and direction of movement, the current flowing through the armature will be a constant, regardless of whether the full line voltage is impressed upon the armature, or only a part of it by connecting resistances in the armature circuit, provided that the field excitation remains unchanged, although it is of course reduced by increasing the field strength. This is due to the fact that a practically constant torque is required to keep the elevator system in motion at any speed, and this torque is a function of the field flux and armature ampere-turns only, the speed alone varying with a change of armature voltage. The armature current when running at the slow speeds obtained by the use of the series and shunt or by-pass resistances can therefore in no case be less than that required to run the elevator under the same condition of load and direction of movement with the full line voltage across both armature and field terminals, that is, at maximum field strength.

The great waste of power in reducing the speed by this method is self-evident, but is so important and so much more than it would appear to be from a casual examination, that a few specific cases will be pointed out, in comparison with the energy required under the same conditions by a geared machine having speed control by field variation only. It will be assumed that the normal car speed is 600 ft. per min., and that both machines have traction sheaves 36 in. in diameter, running therefore at about 64 r.p.m.; that the 1:1 machine is driven by a motor so designed that the sheave runs at 45 r.p.m. at maximum field strength, giving a car speed of 424 ft. per min.; and that the geared machine is driven by a motor so designed that the sheave runs at 18 r.p.m. at maximum field strength, giving a car speed of 170 ft. per min. The latter speed is low enough to permit stopping the car at landings with sufficient accuracy, but as 424 ft. per min. is entirely too high, armature resistances must be used with the 1:1 machine to get a further reduction of speed. In making the comparison the controller contact, brush, and armature copper resistances will be disregarded, as these, while having a slight bearing on the case, are not of sufficient importance to affect the results materially. The assumption will also be made that both machines will take the same armature current to lift a given load in the car at a given speed, provided that this speed is not less than 424 ft. per min., the full field strength speed of the first machine.

No diagram is necessary to show the circuits when no armature resistances are in use, as the brushes are connected directly across the line. Currents flowing from left to right in Fig. 41 showing the connections of the armature resistances, are marked plus (+) in the Tables, and those flowing from right to left are marked minus (—). Line currents marked plus (+) therefore represent power drawn from the line, and when marked minus (—) indicate power returned to the line, and this is also the case with the line currents given for the second machine, with which no armature resistances are used, and for the first machine when running with full line voltage across the armature. The overbalance, or excess of counterweight over the weight of the car, has been assumed to be 1000 lb. for both types, although the geared machine is usually operated with less overbalance

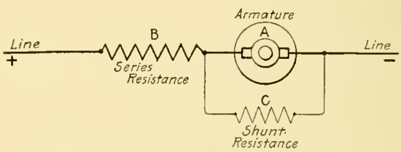



Fig. 41 Diagram of Series and By-Pass Armature Resistances

owing to its larger sheaves and greater traction. The net loads which must be handled by the machine, given in the second column, are therefore 1000 lb. less than the gross loads in the first column, being indicated as positive when the greater load is on the car side, and as negative when the excess is on the counterweight side. Considering movement of the car upward as positive and movement downward as negative, if the product of the signs representing load and direction is positive, the machine will be called upon to do work, as it will be lifting the weight which is greater, but if negative, the greater weight will be descending, and current will be generated in the armature.

A comparison of these figures shows that for every condition, the machine using the armature resistance, that is, the 1:1 or gearless type, takes more power as soon as these are connected in the circuit, and even though the other machine may be generating current at slow speed and returning it to the line, this gearless machine will still require a very considerable amount of power to be supplied. The moment the shunt resistance circuit is closed, whatever current the armature generates flows around it, and the reduction in total power used by the elevator that might be secured, is lost. The machine runs under this slow speed condition every time a terminal landing is approached, the automatic limit switches being set to slow down the machine at a safe distance from the floor and to cover all conditions of load, this distance is greater than an operator would require to stop the car at an intermediate floor, although in making inter-

mediate stops this condition obtains and depends upon the operator's skill in judging the correct distance from the floor to bring the car switch to the *slow* position.

In Table 1 it has been assumed that the resistances could be varied just as required to get the desired 90 volts across the brushes, but in practice this cannot be done so accurately. Approximations must be made and the speed with different loads will show a wide variation. It is necessary as well to depend upon the operator's good judgment to select the correct point on his car switch for the load in the car at the time. In comparison with this uncertainty, we have, in the geared machine, a fixed maximum field strength, giving a definite slow speed with all loads automatically, subject only to the slight variations found in a well-designed shunt motor, which are negligible.

Considering now what becomes of the kinetic energy in the moving masses when reducing the car speed by either of the methods that have been described, we find that when this is done by strengthening the field, with the armature still connected directly across the line, exactly the same result is obtained as when an unbalanced load is driving the machine; that is, current is generated in the armature and returned to the line, or if the machine is lifting a heavy load there will be a reduction in the line current, which amounts to the same thing. All of the energy that was used in accelerating the complete elevator system from the full field to the maximum speed will be returned, less the losses in the armature and gears only. As this kinetic energy varies as the square of the velocity, it will be found that the proportion of the total accelerating energy that will be thus returned by field strengthening, for the two machines we have been considering, will be 50 per cent for the first machine of the gearless or 1:1 type, with a full field car speed of 424 ft. per min., and 80 per cent for the second or geared machine, with a full field car speed of 170 ft. per min. The remaining kinetic energy cannot be usefully recovered from either machine. Although the first machine will be slowed down to 170 ft. per min. before disconnecting it from the line, thereby generating energy in the armature equal to about 30 per cent of the original total accelerating energy, it has been seen that this will all be dissipated in the resistances; none of it can be returned to the line on account of the shunt around the armature, but on the contrary, additional current will be drawn from the line through the series and shunt resistances. The energy remaining in the system when the line circuit is finally opened with the car running at 170 ft. per min. is of course lost in the dynamic braking resistance and the mechanical brake, but as this is only about 20 per cent of the original total accelerating energy, its loss is comparatively unimportant.

TABLE 1 CURRENT TAKEN BY 1:1 MACHINE USING ARMATURE RESISTANCES FOR SLOW SPEEDS

| Gross Load in Car | Net Load | Direction of Motion | Car Speed Ft. per Min. | Volts Across Brushes | Field Excitation | Series Resistance *B* Ohms | Shunt Resistance *C* Ohms | Amperes in Armature *A* | Amperes in Series Resistance *B* | Amperes in Shunt Resistance *C* | Line Circuit Amperes |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | −1000 | Up | 424 | 225 | Maximum | . | .. | −25.0 | .. | .. | − 25.0 |
| | | | 170 | 90 | " | 2.0 | 0.97 | −25.0 | + 67.5 | + 92.5 | + 67.5 |
| 0 | −1000 | Down | 424 | 225 | " | .. | .. | +52.0 | .. | .. | + 52.0 |
| | | | 170 | 90 | " | 1.0 | 1.08 | +52.0 | +135.0 | + 83.0 | +135.0 |
| 1000 | 0 | Up or Down | 424 | 225 | " | .. | .. | +12.0 | .. | .. | + 13.0 |
| | | | 170 | 90 | " | 1.5 | 0.90 | +12.0 | + 90.0 | + 78.0 | + 90.0 |
| 2500 | +1500 | Up | 424 | 225 | " | .. | .. | +77.0 | .. | .. | + 77.0 |
| | | | 170 | 90 | " | 1.0 | 1.55 | +77.0 | +135.0 | + 58.0 | +135.0 |
| 2500 | +1500 | Down | 424 | 225 | " | .. | .. | −41.0 | .. | .. | − 41.0 |
| | | | 170 | 90 | " | 2.0 | 0.83 | −41.0 | + 67.5 | +108.5 | + 67.5 |

The armature shunt resistance also takes its toll every time the car is started, as well as when stopping, for having been left connected across the armature when the line circuit was opened, it is still there when the line is closed, and until the contactors controlling it have operated, part of the starting current flows through it, doing no useful work.

Now may be considered the possibilities of the alternate method first suggested, that is, the use of a moderate speed motor, driving the traction sheave through a suitable gear reduction. It is well known that machines of this kind, employing worm gearing, have been in general use for many years, and have proven beyond question their adaptability for service at moderate speeds. The durability and efficiency of well-designed worm gearing are quite surprising, and there is no doubt but that it would be entirely satisfactory for any car speed allowed by city regulations, if properly applied. The writers believe that worm gearing will be used for a long time to come for moderate speed machines, but when the car speed is 350 ft. per min. or more, it becomes desirable to use another kind of gearing, which recent developments in manufacturing methods have made it possible to produce economically and accurately, having a much higher efficiency and

TABLE 2 CURRENT TAKEN BY GEARED MACHINE USING FIELD CONTROL FOR SLOW SPEEDS

| Gross Load in Car | Net Load | Direction of Motion | Car Speed Ft. per Minute | Volts Across Brushes | Field Excitation | Amperes in Armature *A* and Line Circuit Amperes |
|---|---|---|---|---|---|---|
| 0 | −1000 | Up | 424 | 225 | 40 per cent | −25.0 |
| | | | 170 | 225 | Maximum | −10.0 |
| 0 | −1000 | Down | 424 | 225 | 40 per cent | +52.0 |
| | | | 170 | 225 | Maximum | +21.0 |
| 1000 | 0 | Up or Down | 424 | 225 | 40 per cent | +12.0 |
| | | | 170 | 225 | Maximum | + 5.0 |
| 2500 | +1500 | Up | 424 | 225 | 40 per cent | +77.0 |
| | | | 170 | 225 | Maximum | +31.0 |
| 2500 | +1500 | Down | 424 | 225 | 40 per cent | −41.0 |
| | | | 170 | 225 | Maximum | −16.0 |

extreme durability, with perfect certainty of smoothness of operation, when properly designed and constructed. By this reference is had to the double helical or herringbone gear reduction.

This form of gearing is now so well known that it is unnecessary to describe it in detail, as since it was found that it could be produced so easily by the hobbing process, it has rapidly come into general use, and has been applied with entire success under the most exacting conditions of service, such as driving the propellers of steamships, where the safety of the ship is dependent upon the unfailing transmission of the power controlling its movements; or for reducing the speed of steam turbines, in which the velocity is so high that no other form of gearing can be used; or for driving rolling mills, where the severe shocks would be destructive to any other kind of gears. It owes its remarkably high efficiency and perfectly smooth operation to the continuous rolling pitch line contact of the teeth, which are so proportioned that several are always in engagement at the pitch line, at which practically all of the pressure between the teeth is transmitted without loss of power from sliding or slipping between the load-carrying surfaces. This absence of slipping also explains why gears of this type are practically free from wear.

Here it is desired to correct the impression left by the author's curves of the efficiency of herringbone gears. These apparently indicated that the gears have an efficiency of only 88 to 91 per cent—values far below those regularly obtained in good practice, which are found to be from 98 to 98.5 per cent, as determined by the writers' tests. These figures are substantiated by numerous other tests made by competent engineers, showing that when properly designed and manufactured, gear reductions of this type may confidently be expected to show an efficiency of 98 to 99 per cent. A report of tests that may be cited is one made by the Westinghouse Machine Co. on a gear reduction suitable for the propeller drive of a steamship,[1] which test showed an efficiency even higher than 98 per cent. The author said that about 1.5 h.p. was required for the agitation of the lubricating bath in which the gears run, but such a loss of power is many times the attainable minimum with thorough lubrication, which is secured by the use of a small amount of relatively light-bodied oil. As a matter of fact, the total power lost in the gear reduction complete, including the rolling tooth friction, oil agitation, and turning the main shaft in its bearings, is only about 0.5 h.p. at full load; that is, when transmitting about 35 h.p., if the gears are properly designed and manufactured.

The author also said that worm gearing was preferable to double helical gearing because it offered greater certainty of smoothness of operation. Emphatically this is not the case, and in any elevator with a machine employing well-made gears of this type, it is impossible to detect their presence, as the smooth floating motion of the car is fully equal to that of any hydraulic elevator, while on the other hand it is a well known fact that worm gearing used in elevators very often results in a trembling motion of the car, which it is difficult to remedy. In answer to the implication that gears should not be used if it is in any way possible to get along without them, a well-known manufacturer of apparatus using herringbone geared drives is quoted herewith: "While there is a general and natural objection to the introduction of gears where they can be avoided, yet here, as in all branches of engineering design, the advantages and disadvantages of one form of construction have to be balanced against those of another before a final judgment can be passed. In other words, the use of gears eliminates certain undesirable features; therefore, if gears can be made that will perform the duty, with low cost for maintenance, high efficiency and requiring little attention, is not the use of such gears the logical procedure?"

It is conceivable that if one setting out to design an automobile, allowed the obsession that gears must not be used to run away with his good judgment, he might succeed in producing a car that would run, but no right-minded engineer considers such a course for a moment. He designs a motor for the speed at which it will show the best operating characteristics, and transmits its output to the driving wheels through suitable gearing, properly designed for the functions it must perform. The prediction is hazarded that if electric cars come to take the place of the gasoline cars now generally used, the design adopted will not be one using a motor directly connected to each rear wheel. Outside of this gearless elevator, we have no examples of moderate or slow speed machinery driven by direct connected electric motors. Such a construction is used only for high speed machines, such as speed lathes, grinding and buffing wheels, and the like, which run at speeds equal to those of motors of standard design.

The author gave some figures on the accelerating energy required in starting a machine of the geared type as compared with a 1:1 machine. He gave 3060 foot-pounds as the energy required for the sheave and gear alone, and a total of 13,400 foot-pounds for the complete machine, against 2450 for the complete 1:1 machine. There is evidently some discrepancy in these figures, as it is apparent at a glance that the 1:1 armature with its traction sheave and large brake pulley will require far more accelerating energy than the much lighter gear and sheave, running at the same number of revolutions per minute. These figures really should be about 2200 foot-pounds for the gear and sheave, and about 3800 foot-pounds for the complete 1:1 machine.

While it is admitted that the geared machine will require somewhat more energy for acceleration than the 1:1, the difference is shown in correct relation to the total work of acceleration when added to the energy required to lift the unbalanced load in the car during the accelerating period of 2.5 or 3 seconds, and that required to accelerate the vertically moving masses, consisting of the car, load, counterweight, and lifting and compensating ropes, the total weight of these being, on the average, about 14,000 lb. As the maximum net load the machine will lift is usually about 2000 lb. and the distance traveled by the car while accelerating about 9 ft., the work the motor must do to overcome this resistance will be 18,000 foot-pounds, while the work of accelerating the 14,000 lb. of vertically moving parts to a speed of 600 ft. per min., or 10 ft. per second, will be about 21,800 foot-pounds. Adding to these the accelerating energy for each of the machines, including an allowance for the idler and compensating rope sheaves, we get for the total work done by the motor during the time taken to accelerate the elevator, about 44,800 foot-pounds with the 1:1 machine, and about 56,500 foot-pounds with the geared machine, these figures being roughly in the ratio of 4 to 5. The kinetic energy in

[1] Engineering News, December 30, 1909.

all the moving masses is about 26,800 foot-pounds with the 1:1 machine, and about 38,500 foot-pounds with the geared machine.

It has previously been pointed out, however, that when slowing down preparatory to stopping, a much greater proportion of this energy is returned to the line by the geared machine, which has field control only, than by the 1:1 machine, using armature resistances. It was shown that the geared machine would return to the line 80 per cent of the original total accelerating energy, less armature and gear losses, so, assuming these to be about 6 per cent, we will get credit at the wattmeter, or at some other machine, electrically, of course, for about 29,000 foot-pounds. The balance, or net charge for acceleration, is therefore 38,500 minus 29,000, or about 9,500 foot-pounds. But the 1:1 elevator will return only 50 per cent of its energy, so allowing for the same loss as above, about 12,600 foot-pounds will be returned, and the net charge against this machine for the start is therefore 26,800 minus 12,600, or about 14,200 foot-pounds,—just about one-half more than was charged to the geared machine, which has again shown its superiority. It should be remembered, however, that this does not take account of the loss of power in the 1:1 machine in the current drawn from the line while the armature resistances are in the circuit.

A careful consideration of the advantages that are secured by the use of a moderate speed motor which may be designed for any desired speed variation entirely by means of field weakening, without exceeding reasonable limitations as to weight and space occupied, in combination with a double helical gear reduction driving a traction sheave which may be as large in diameter as desired, as against the direct connected, or 1:1 machine, with the many disadvantages that have been pointed out, will, it is felt, convince any fair-minded engineer that the former is the logical construction to adopt. The results which have been obtained in actual service with the herringbone geared type traction elevator, embodying these principles, have proven beyond a doubt the correctness of this conclusion, as the ease of control, high efficiency from line to load, and small energy consumption per car mile have not only equaled, but exceeded all expectations. A line-to-load efficiency within 0.2 or 0.3 of 77 per cent has been obtained with machines which had been running only a short time, and as the efficiency invariably rises after the elevator has been in service for a few months, it is practically certain that an efficiency of 80 per cent will be reached. High speed machines of this type in office building service are operating regularly on the remarkable low power consumption of from 1.8 to 2.4 kilowatt hours per car mile, with acceleration and retardation as rapid as may be desired, and giving perfect satisfaction to owners and tenants.

In conclusion, some of the advantages of the double helical geared machine, as compared with the 1:1 machine, may be summarized as follows:

*a* Less space occupied in the building.
*b* Less expensive supports and pent-house construction.
*c* No traveling crane needed.
*d* More efficient motor design possible.
*e* Commutation better.
*f* Mechanical brake less troublesome.
*g* Control of car speed secured entirely by field-weakening, against wasteful armature resistances.
*h* Car runs at a definite speed when running slow, insuring more accurate stops.
*i* Higher line to load efficiencies.
*j* Less energy required per start and stop.
*k* Lower cost of operating on account of smaller energy consumption per car mile.
*l* Less rope wear.

In regard to the objections that have been raised to the use of gears of the type selected for these machines, attention is called to their general and constantly increasing use under the most severe and exacting conditions of service, with entire satisfaction; their remarkably high efficiency, with losses so small that they are offset, many times over, by economies they permit in other parts of the apparatus; their extreme durability, running for long periods under heavy loads and showing practically no signs of wear; their perfect smoothness of operation, which makes it impossible to detect in the car that gears have been used in the machine; their freedom from noise and vibration; and the fact that they require no attention other than an occasional small supply of lubricant. The objection to the use of gears of such qualities are so slight as compared with the many substantial advantages that their adoption for the purpose is considered fully justified, and it is felt that as the characteristics of the machine they make possible become more generally appreciated, they must inevitably be accepted as the logical and best type for high-speed service.

The Author. In reply to the question with reference to the rope strain, I might say that by the remark that under ordinary conditions the safety factor was never less than 12, I meant the apparent safety factor with the load at rest. I did not in that statement take into account the additional stress due to acceleration and bending of the rope. That will, of course, materially reduce the apparent safety factor. If the acceleration curves shown for one particular elevator are analyzed, the additional stress due to acceleration can be determined. The stress due to bending over the rotating sheave has been approximately determined and it is not as high as is usually thought. The reason for this is that each wire is not subjected to the same strain by bending it over a sheave, as if it were a single straight wire bent over the sheave. The wire is wound up in a double spiral; the first spiral is the original spiral in the strand, and the second spiral is part of the strand itself, making really a coiled spring wound up into another coiled spring, which, of course, materially reduces the stresses due to bending.

During the last two years I have steadily tested ropes of different construction to determine the actual stresses and to determine the wearing qualities, etc. It is a subject that is altogether too deep to touch on in a few minutes, because one cannot do it justice. I may say, however, that the testing of the ropes referred to brought about some most surprising conclusions. Due to these tests I think it may be predicted that in the near future ropes employed in connection with elevators will be of different construction from those which have been used up to the present time.

Going back to the question of safety factor, if the apparent safety factor is 12, I may say the real safety factor is hardly over 8.

The rate of acceleration can be determined from the curves illustrated. I do not remember what the rate was in any par-

ticular instance, nor can I say offhand what the rate of acceleration is in any particular building, because it varies considerably. It varies with the weight of the car, the rise, the quantity of rope, and also with the service. I may say that in the Hudson Terminal Building, for example, was observed the most rapid acceleration of any electric elevators in New York City. I have determined the rate of acceleration of these elevators, and if of any particular interest it may be published at a later date.

In reference to the employment of alternating-current in electric elevator service, up to the present time no alternating-current elevators of the direct connected or gearless traction type have been put upon the market. Those that have been put on the market have been of the geared type, for speeds up to 350 ft. per min. approximately. For 250 to 350 ft. speed, two speed alternating-current motors are employed, with a speed variation of from 1 to 3 down to 1 to 4. The slowing down or the changing in speed from the full speed down to one-third or one-quarter speed is obtained by rearranging the connections of the motor in such a way as to change from a small number of poles giving the high speed to a large number of poles giving the slow speed. During this change of speed, power is actually generated back into the line, in a similar manner as in the case of a direct-current machine, when the motor field is strengthened for the purpose of speed reduction.

There was at first considerable difficulty in eliminating an objectionable shock due to reducing the motor speed to one-quarter in one step, but by proper design of motor and controlling apparatus, this was successfully accomplished.

With reference to the smooth application of the brake, no known method, at least no method known to me, has been used for magnetically retarding an alternating current brake. There we have to resort to dashpot retardation. In the majority of cases, the brake magnet parts are enclosed in oil tight casings and the brake magnetic cores are utilized as plungers to obtain dashpot action. So far as I know, this is about the only way at the present time by which a comparatively smooth application of the brake can be accomplished in connection with alternating current machines.

I may say that last year I built a gearless alternating current traction machine, but it was not designed on exactly the same lines as the direct-current gearless traction machine. It consisted of one continually revolving motor and one starting when the elevator was started and running when the elevator ran. Half of the outfit consisted of an alternating current motor, which at the time that it acted as a motor acted also as a converter. The other half of the machine consisted practically of a direct current motor having a revolving field with unusually great field variation and speed regulation. The machine was built and tested, and, so far as the speed control was concerned, it was perfect. Field regulation, from no speed up to full speed could be had; in other words, any desired speed could be obtained without resorting to control of resistance in the armature circuit. On the other hand, the losses were comparatively high and the efficiency was not very good. As far as smoothness of operation was concerned, the machine was entirely successful, but the cost of operation was comparatively high. As a matter of fact, considering first cost and power consumption together, I do not consider the machine a commercial proposition; as good results and perhaps better could be obtained by changing the alternating current by means of converters or motor generator sets into direct current and then operating direct-current elevators. The reason why this line of experimentation was temporarily abandoned was simply because it appeared very doubtful whether this type of machine could be of use commercially, even though, from a technical point of view, it proved a complete success.

The discussion by Messrs. Gurney and Callaway lends itself to comment. Presumably, in their remarks, they did not mean to imply that the use of driving sheaves a few inches less in diameter than those assumed would result in a decrease of tractive effort, slippage and undue wear of ropes. Under normal condition, the unbalanced load which can be lifted by a traction sheave without slippage of ropes depends on the arc of contact in degrees. It is independent of the diameter of the sheave, except to a slight extent; that is, increasing the diameter of the sheave may reduce the pressure per unit length of rope in contact to the extent of allowing the film of lubricant to reduce the effective traction.

Having omitted mention of the number of starts per car mile made by the elevator, their reference to a consumption of 1.8 to 2.4 kw.-hr. per car mile is somewhat lacking in significance. This will be apparent upon referring to curves in Figs. 28 and 29.

The gearless 1:1 traction machine is intended primarily for high speed, high rise service. For this service, on account of its uncommonly high efficiency (especially with average or less than half load), low power consumption and satisfactory operation, it far excels all other types of elevator machines yet developed. It is not intended to supplant the geared type of machine in its particular field of comparatively low speed and rise. In other words, the interests of clients are best served by having both types available for choice, depending upon a careful consideration of particular requirements. Manifestly, there is a field intervening that of the gearless 1:1 traction and the regular worm geared type of elevator which may be covered by either of them. When, therefore, the load required is heavy, the speed desired is between 250 to 450 ft. per min., and the service is severe—making a reduction in power consumption an important consideration, justifying a reasonable increase in first cost of plant—the use of a gearless 2:1 traction machine is most appropriate. This 2:1 type of machine combines the advantages of high efficiency (with average as well as full loads), comparatively low kinetic energy and consequent low power consumption with requirements for lower speed and corresponding heavier loads.

The efficiency of a complete installation of a gearless 2:1 traction machine is only slightly less than that of a 1:1 equipment. The decrease is due to the bearings of the sheaves mounted on the car and counterweight. These bearings are of the ball bearing type, and the friction and oil losses thereof are evidently less than those due to worm or herringbone gears. The machine of the 2:1 outfit is practically the same as that of the 1:1. The 2:1 roping is used to obtain car speeds of 250 to 450 ft. per min., instead of speeds of 500 to 700 ft. per min., usual with the 1:1 outfits. The rope speed also is practically the same in both. Both, therefore, employ low speed motors; and it should readily be apparent that the use of a 2:1 arrangement is not "an admission that the higher speed motor has advantages over the abnormally slow."

Exception has been taken to items in the tabulated comparison of the kinetic energies of a herringbone geared and

a gearless machine, presented in the paper. These tabulations were intended to be indicative of two particular machines suitable for the same load and speed. The herringbone gear was large in diameter and of substantial construction. Its weight resulted in the high energy of 2060 ft.-lb. This result, as well as all the other kinetic energies given, was derived from careful tests made in the manner described. They represent actual facts and not mere assumptions. Since it appears of interest, a similar tabulation of the complete installation, also, is here presented:

| | Kinetic Energy in Foot-pounds (600 ft. Car Speed) | |
|---|---|---|
| | Herringbone-geared Machine | Gearless Machine |
| Motor armature | 7420 | 2450 |
| Brake pulley | 2920 | |
| Driving sheave | 1000 | |
| Herringbone gear | 2060 | |
| Secondary and compensating sheaves | 1865 | 1865 |
| Car and counterweight on balanced load condition | 15,500 | 15,500 |
| Ropes | 880 | 880 |
| Total | 31,645 | 20,695 |

The ratio between these totals is as 6.13 is to 4 and not 5:4, as indicated in the discussion. As the use of the herringbone-geared or the gearless machine does not entail material differences in the design or layout of car, counterweight or other hatchway units, a comparison of the differences in the machines only was deemed most representative of their relative merits for elevator service and possible effect on power consumption.

Since the kinetic energy of a low speed motor is less than that of a high speed motor, the former may be brought to rest by the dynamic and mechanical brakes, with relatively less electric and friction losses and relatively less wear on the brake shoes, than may the high speed motor, even though the brake itself be, as a matter of fact, larger and more powerful.

That "the difficulties encountered in designing a motor for an output of from 30 to 40 horsepower, at a speed of 50 to 60 rev. per min.," may be successfully overcome is perhaps fully illustrated by Figs. 6 to 9 and the curves in Figs. 10 and 11. Fig. 11 relates to a motor rated at 75 h.p. running at 89 r.p.m., which had an efficiency of over 90 per cent at anywhere from merely 30 per cent of its capacity to considerable overload. The variation in car speed when ascending and descending with full load is within 5 per cent of the average speed.

In the discussion, there appears to be advocated reduction in motor speeds of $3\frac{1}{2}$:1 (64:18) by means of field regulation only. From our experience with high speed shunt field motors, we should judge that so great a reduction by means of field regulation only would prove somewhat unsatisfactory, particularly for normal running conditions. With the low speed motors we use, we have, however, successfully accomplished a speed reduction for stopping of fully 2:1 by means of field regulation only.

It should be noted that a small amount of speed reduction by field regulation is more effective in stopping a low speed motor than is a greater proportionate speed reduction by field regulation with a high speed motor. This is due to the fact that facility, or difficulty, in making accurate stops depends on the amount of energy stored in the moving parts, rather than merely on their speed.

Their argument tends to convey the idea that the energy required for accelerating the elevator masses during the period of starting is available for recovery during the period of stopping, and that the gearless machine, having less speed reduction by means of field regulation, dissipates in armature resistance more of the energy available for recovery than does the geared machine, and therefore consumes in effect more power. Their conclusions appear to have been influenced also by the erroneous assumption that series and bypass armature resistances are employed during starting.

For investigating the accuracy of their conclusions, an example may be given. For instance, let us consider the kinetic energies of the two installations to be as already tabulated, namely: 13,400 ft.-lb. for the herringbone geared machines, 2450 ft.-lb. for the gearless machine and 18,245 ft.-lb. for the hatchway units. Let us assume the motor and contactor efficiency of each installation to be 85 per cent, the gear and hatchway efficiency of the geared machine 75 per cent and the hatchway efficiency of the gearless 85 per cent. Moreover, let us assume a speed reduction by field regulation only of $3\frac{1}{2}$:1 for the geared machine and 2:1 for the gearless.

Manifestly, the energy required by the motor for accelerating the elevator masses of the geared machine may be expressed as follows:

$$\frac{13400 + \frac{18245}{0.75}}{0.85} = 44{,}300 \text{ ft.-lb.} \qquad (1)$$

and that of the gearless:

$$\frac{2450 + \frac{18245}{0.85}}{0.85} = 28{,}200 \text{ ft.-lb.} \qquad (2)$$

Evidently also, the energy available for recovery during the period of speed reduction before stopping may, for the geared machine, be expressed as

$$0.85\ (13400 + 0.75 \times 18245)\ (1 - 1 \div 3.5^2) = 21{,}100 \text{ ft.-lb.} \qquad (3)$$

and, for the geared machine:

$$0.85\ (2450 + 0.85 \times 18245)\ (1 - 1 \div 2^2) = 11{,}450 \text{ ft.-lb.} \qquad (4)$$

Finally then, the difference between equations (1) and (3) and between (2) and (4) will indicate the net amount of power consumed by each elevator during starting and stopping. That is, the net amount consumed by the geared machine may be represented by 44,300 — 21,100 = 23,200 ft.-lb., and that consumed by the gearless, by 28,200 — 11,450 = 16,750 ft.-lb. The latter is only about 72 per cent of the former. This example indicates that even with less field regulation, the gearless machine consumes considerably less power for starting and stopping; and it is obvious that its efficiency is superior during running.

In response to Mr. Erlich's request the story heights of the Adams Express Company's building averaged 13.2 feet.

# APPLICATION OF ENGINEERING METHODS TO THE PROBLEMS OF THE EXECUTIVE, DIRECTOR AND TRUSTEE

BY DR. HOLLIS GODFREY, PHILADELPHIA, PA.

Member of the Society.

THE problem considered in this paper is the expression of an endeavor to determine the methods by which the service of a consulting engineer may be made of greatest value to the executive of a corporation, or to a board of directors or trustees, during an interregnum in the executive office. In taking a more or less comprehensive view of problems which have confronted certain executives, and mapping out plans coöperatively with them which they could present to their directors, to their subordinates, and to their constituents, I have been forced to a regular method of procedure made practicable through coöperation of the executive and the consulting engineer. This method, which, after an experience of several years, has proven its value in money and in service, is briefly as follows:

*a* The defining, on the basis of facts shown by engineering study, of the policies of a business.

*b* The expression in simple, usable form of the definitions obtained.

*c* Construction on the basis of the studies made.

### THE NEED FOR DEFINITION

The need for an executive to have definitions before he can make decisions is often forgotten. No executive is doing the most he can do for his business until he has obtained his definitions, by having his business fully surveyed and his fields of action selectively mapped, until he has located to the best of the present state of engineering and of industry the places where waste exists and where the greatest possibility for profitable development lies.

Such broad study, to be fully effective, must come from the coöperative use of the best methods known to engineering and to industry, through such coöperation between the industrial executive and the consulting engineer as shall combine the best of the inside industrial view of the business in question and the best of the outside view of applied science. Such a study must include or be followed by the vital but often neglected comparative and selective studies, which show what pays and what does not. To define what is to be kept and what dropped is essential to a successful business. Too often the rule is to keep everything; such a policy may have been possible in the old days of big profits, but it is no longer possible today.

### THE NEED FOR EXPRESSION

To express a definition is almost, or quite, as necessary as to define, for an executive has especial reason to make his meaning clear. First and foremost, his policies must be so clear in his own mind that he can properly place them before the board of directors or trustees, if these bodies are to legislate wisely and well upon the policies placed before them. Again and again problems involving very considerable sums of money come before boards of trustees and directors, where the time of discussion of the question is limited to from one to three hours. The executive is the person to bring these problems before the board; and in order to choose wisely between different policies, in order to enable the directors to see what should be done, and to lay down a policy for the institution, the facts used must be so well chosen and selected that there can be no question of their value, and so clearly and so completely presented that their meaning can be given to a board in the shortest possible space of time.

Expression to the board of directors is but one of the problems. An executive has another duty which is often forgotten,—whether he will or no, his immediate task must be largely that of training his subordinates, of educating the men who are to work with him in the different policies of the business so that the whole staff shall work in harmony and each one understand what is behind the different policies which affect the sales, operating, and accounting departments. If the executive has not defined and expressed his policies in so simple a fashion that all his force is working in harmony, the lost motion ensuing means a loss in money which is amazing to contemplate. In many corporations, the executive has another duty, because in this day of the interest of the public and of the Government in corporation affairs, it is again and again essential not only that proper facts should be chosen, but also that those proper facts, once chosen, should be properly translated and expressed in a form which will reach a given audience, especially the broad audience of the public. Too often today such selection and expression of facts is wanting, and instead a theory or a case is presented, which may be met and conquered by another theory or another case.

### COÖPERATIVE CONSTRUCTION

Money saving and money making—time saving and improvement of service—all these are intimately concerned with proper definition and expression of the facts about a business. When such definition and expression has been made, strong constructive work can be done and all three factors, definition, expression, construction can best be upbuilt through the application to industrial needs of the best that modern science and scientific methods has produced.

It cannot be too strongly emphasized that such applications of science to industry as are here outlined can best be accomplished through the coöperative efforts of engineers trained for years in science, in various types of industry and in the application of science to industry and of corporations willing to devote to such coöperative endeavor the cordial assistance of employees trained for years in the details of their own business. Neither from without nor within can the best results be secured. Advances can best be made through the welding together of the two types of knowledge possessed by two groups of men, one possessing general knowledge of science and industry and one possessing specific knowledge of a given business.

Presented at the New York local section of the AMERICAN SOCIETY OF MECHANICAL ENGINEERS on March 9, 1915.

#### METHODS OF PROCEDURE

There are six divisions, as I have seen them develop, which very much concern a consulting engineer who is serving any corporation along these lines. The final thing is, of course, the decision, and it is the executive or the board who knows five or ten per cent more than the other man who decides promptly, and in most cases decides rightly. It is, then, a function of the consulting engineer to present such facts to the executive that the basis of the decision made may be as sound as possible; he should place before the executive:

*a* A general preliminary coöperative study of the field to determine what lines are most worthy of study.

*b* A coöperative determination of what facts should be known about the lines selected and a definition of the periods most worthy of study on the basis of the preliminary study.

*c* A careful collection and intensive study of the facts existing in the lines chosen for the periods determined.

*d* The translation of the facts collected and studied in the light of their relation to the other departments of the business.

*e* The expression of the facts studied and the results obtained, in the briefest and clearest way.

*f* A method for the constructive use of the facts obtained and where necessary, an expression of the facts in a form intelligible to the special audience which needs most to know them.

#### THE TASKS OF EXECUTIVE AND ENGINEER

Turning to the first heading, the need for a broad, comprehensive view of the whole problem, it seems to me that every executive must realize the fact that it is his task to determine the internal policy and the external policy of his company, and that those policies, which make up the policy of the business, must rest primarily upon the history of that business and upon the facts of the business and its relation to its world. He should also realize that he can best obtain the necessary data as to both history and facts through the coöperative assistance of the engineer. No consulting engineer can possibly know as much of a given business as can men who have been trained for years in that business; but it is equally true, though sometimes forgotten, that no business executive can know as much of scientific methods as applied to industry as the engineer—each has his own knowledge, his own training, his own experience. One has the inside viewpoint; the other, the outside viewpoint. Neither can do a complete job alone. The peculiar value to industry of the engineer who possesses training and experience comes largely from the fact that such an engineer can choose the most vital physical facts and bring them into such relation that they may be clearly and briefly expressed, and because the engineer's knowledge makes possible the discarding of useless statistics. The need for training and experience in the determining of what facts to collect and what lines to study can hardly be made too emphatic.

The problem, then, for the engineer, is to use his viewpoint, to use the scientific method undimmed by too much technique of the business, coöperatively with the executive in the collection and translation of the facts, to bring the essential factors from the cloud of nonessentials, and to define and express the clear-cut, sharp, comprehensive policies which should be pursued.

PRELIMINARY WORK

- A Statistical Studies
  - Space — Study of Geographical Area
    - Classification of Streets — Widths; Pavements; Nature of Travel; Character of Abutting Buildings
    - Classification of Street Intersections and of Public Places — Area; Angles of Intersecting Streets; Character of Abutting Buildings
    - Movement of Building Development
    - Present Conditions
  - Men — Study of Densities of Population
  - Money — Study of Unit Cost per Street Mile for Different Classes
  - Miscellaneous Facts — Study of Location of Existing Lamps — Personal Inspection; Official Records; Contractors' Records
- B Experimental Studies
  - Areas — Illumination per Unit Area for Different Classes of Streets and of Street Intersections
  - Population — Traffic Census
  - Intensity of Light and Light Sources — Unit Intensity per Unit Population per Unit Area
- Correlation of A and B — The Second Step

Fig. I Chart indicating Statistical and Experimental Studies used in an Investigation of a City Lighting System

The problem for the executive is to aid the engineer by giving him the facts about the business, and by assisting him in determining the practicability of his suggestions. It must be remembered also that both executive and engineer must be open minded, if coöperation is to succeed. It is comparatively seldom that an engineer is asked to lay out a wholly new plant. He is generally doing the best he can with an old one.

One may often see in the records of many corporations the rings of age showing as many periods of growth as the rings around a giant sequoia. To determine the meaning and value of these different rings, to understand their translation, to find out what is orderly growth and what is disease excrescence, to determine what should be fostered, to devise means of loosening cramping bands which have grown up

- Second Step
  - Design and Construction of Trial Installations
    - Type
      - Gas
      - Electric
    - Reflectors
      - Clear
      - Semi-Opaque
      - Translucent
    - Pole Height
      - Limits for Arcs
      - Limits for Low Unit
  - Studies of Results Obtained from Trial Installations
    - Tests
      - C. P. of Light Source
      - Efficiency at Objective Point
    - Costs
      - Relative Maintenance Cost of Various Types
      - Relative Installation Cost of Various Types

Fig. 2 Studies of Lighting Equipment and Results from Trial Installations

around the business,—that task should be done best by the methods outlined here.

There is another reason why the obtaining of a broad comprehensive view is essentially a function of the outside engineer, even where the executive is himself an engineer. I personally believe that no man can get along without an outside view upon his problems, and that the executive is always dimmed by his nearness to the problem. I question whether any sincere man will deny that he has certain preferences for the work he is doing himself, or question that no matter how completely he endeavors to gain an unprejudiced view of his daily routine he is somewhat affected by a glamor of personality.

As I indicated before, the internal view is but one of the factors in the situation. No business lives alone. Not only within the business, but outside the business, any individual institution or corporation whose aims are clearly defined and rightly defended and expressed can remove to a large degree any unpleasant relations with other corporations, with legislatures, with public service commissions, and with the public generally. Such questions as the following are constantly arising: What is the competitor's policy as compared with ours? What is being done in his field, and how does his field relate to ours? What will a legislature or a public service commission do that affects our future? What will the public reaction be upon a given policy? All uncertainty as regards the answers to these questions is largely cleared away when any branch of industry has a clearly set forth and definite policy, clearly expressed, and based upon proper study of the facts not only of its interior but of its exterior relations.

### A BROAD COMPREHENSIVE STUDY

An illustration of a rather broad and comprehensive study made for an executive and a board, the results of a year's study of a problem, which included a survey of the whole field and a selection of those lines which seemed most profitable for investigation, is stated as follows:

*Given a city with one hundred miles of streets and public places to be lighted and with a maximum population of a quarter of a million, provide the best light at the lowest cost.*

In this investigation we first made a preliminary study, and laid out a work chart, Fig. 1, showing certain statistical and experimental studies that we desired to follow out. Under *space* we studied the geographical areas, and made a classification of the streets,—widths, pavements, nature of travel, and character of abutting buildings, taken from the highway plans of various streets, and arranged in groups. We then classified the street intersections and public places, found the areas, angles of intersecting streets, character of abutting buildings, particularly with regard to automobile travel and possibilities of bad lighting at the intersections. We determined the present condition in the case of the streets and intersections and public places.

We then studied the densities of population, and also studied with relation to these densities of population, the movement of building in the last five years and how the building had progressed in different periods and under different conditions in the city. As a matter of fact, the popular estimates of what building had occurred, were largely incorrect until we made this study, and the people of the city thought the facts about the city were quite different from what they actually were. We found that while the movement of building was supposed to be greatest in one direction, it was actually greater in another direction.

We then went on with the question of money, and studied the unit cost per street mile for the different classes of lighting for the different streets.

In regard to miscellaneous facts, we studied the location of existing lamps, from personal inspection, from official records, and from the contractors' records and comparing the city records with the contractors' records. The lighting had gone on as most lighting goes, in a varying manner; one year the appropriation had been large and there had been a lot of lamps put in as a result of new developments started. The next year the development died out, for some reason, and a lot of lamps had not been placed, and some of those which had been put in place were not effectively used. The result was that there was no regular distribution of lighting.

The heading "experimental studies" represents definite

experimental work. We put up adjustable standards similar to those used by the Edison Company, the Electrical Testing Laboratories, and by Mr. Lacombe in the New York City tests, and also similar to various other experimental plants elsewhere. Under "areas," we studied the illumination per unit area for different classes of streets and of street intersections. We studied the population and traffic census, especially with reference to foot traffic and automobiles, and incidentally let me say that in a similar study to this we found one interesting thing where we made a very considerable mistake, one which would have made much trouble if we had not been working coöperatively with the officers of the city, and had not invited them to criticize freely our studies. We took the traffic census on a given road and found there were only eighteen vehicles going up that road. We checked it up, and one of the persons familiar with the situation said, "There is a big mistake there, because that is where the early morning trucking goes." We went back and made the study between two and six o'clock in the morning and found over a hundred trucks coming in over that road, which went out late in the afternoon. In the late

- Answer to Problem
  - The Drawing of Specifications
    - Interchangeable Where Possible
      - Gas
      - Electric
    - Consistent With Local Conditions
    - Comprehensive
  - The Obtaining of Bids
  - The Final Contract
    - Fair and Equitable to City and Contractor

Fig. 3 Chart indicating Answer to the Problem

morning, when the study was taken, there was almost no traffic on that street. There is an illustration of the necessity of coöperating with the people in the place, to find out what the facts are about the actual conditions. If we had not checked that study street by street with the people who knew the conditions, we should have based our lighting for that road on the morning study, and found no traffic worthy of mention.

Under "intensity of light and light sources," we determined the unit intensity per unit population per unit area, and in getting that together there is only one conception, practically, that one should give the executive to use, and that is the conception of the unit. the concept of the candle, because after all our light unit comes back (with full recognition of the carefully drawn and admirable work of the Bureau of Standards), to a concept of a candle, just as density of population or unit population goes back to the conception of one man in one house, and that unit concept can always be given simply and directly. Almost the only thing used in the preliminary work, which needed any translation, was the word "unit," (and we only used that because we had to use the unit concept) and we found that was easily translated, even with the men on the street.

We then took up the question of design and construction of trial installations for both gas and electric lamps, Fig. 2. In the case of reflectors, we studied the clear, semi-opaque, and translucent. We also studied the matter of pole heights, limits for arcs, and limits for low units. We made studies of results obtained from trial installations, and made tests to discover the candlepower of light sources and their efficiency at given points.

In considering the cost of this installation, we then proceeded to a study of the relative maintenance and costs of various types.

The answer to the problem was the final drawing up of specifications, Fig. 3, making the gas and electric units in-

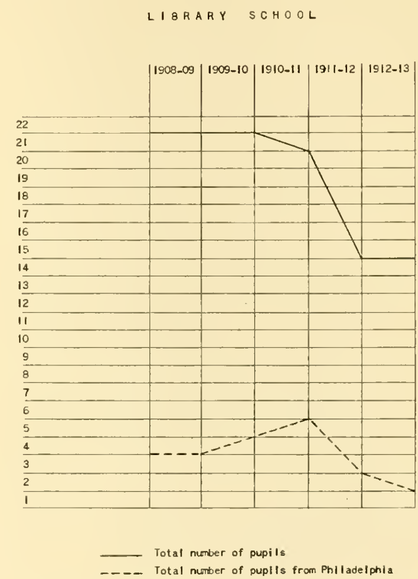



Fig. 4 Student Enrollment for Five Years

terchangeable where possible, and making specifications consistent with the local conditions which did not require tests of an expensive nature to be carried on, and which would be comprehensive. It is impossible in any chart to show all of the different factors which concern specifications in general. Perhaps there is no more dangerous fallacy than the concept that a specification which can be used with great satisfaction in one plan can be used with equal satisfaction in another. The main thing which we desired to obtain was a final contract which should be fair and equitable to both the city and the contractor.

Such a study as I have shown here is a brief representation of my first concept which concerned the possibilities of engineering work done coöperatively with an executive in obtaining broad, comprehensive views for the education of associates, for the public, and for the authorities.

### A SELECTIVE STUDY

The second division of my subject concerns the application of the theory of selection to the different parts of a

problem in such a way as to enable any executive to understand those factors in a business which are more valuable and those which are less valuable. Certainly if there is a branch of engineering which, from the standpoint of money returns, needs most to be applied to industry, it is such studies as shall give readily to the executive and to legislative bodies and corporations that concept of the selective values of their business. There is no way I know by which this can be obtained save through engineering studies of the type illustrated here;—for there are very few businesses which are so simplified that one can tell offhand at a glance what line will pay and what line will not. Such

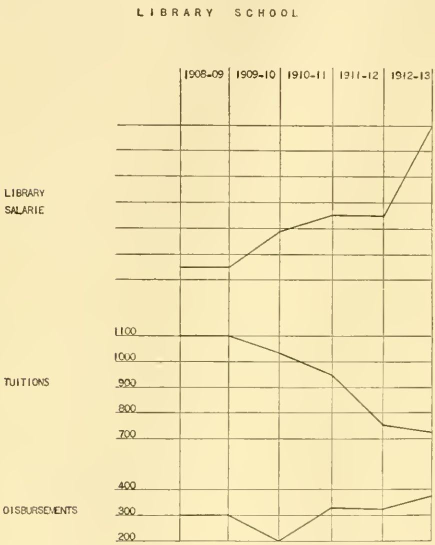



Fig. 5 Comparison of Salaries, Tuitions and Disbursements for Five Years.

studies as those concerned with the possibilities of obtaining raw material, of development of transportation, of the labor market, and of selling fields,—all come into this group and concern such comparative information as shall make selection between different problems possible. Such comparative information as will enable the executive to know which part of the business will be mainly effective, provides the means by which the executive may select what shall be pushed and what shall be held, what shall be dropped, and what shall be left for a future time or for future stimulation. It is upon such selective decisions that again and again large decisions may hinge.

I had made a number of studies of this nature when I went to the Drexel Institute as president, and found there a number of departments which had grown in the same way that most of the departments of the small college grow. There was a period in American life when the small college endeavored to be a university without success. That period is, fortunately, passing, and we are coming to realize that there is a definite place for the small college and a definite place for the university. During that period a number of admirable schools were added to the Institute, and since one of my tasks, when I went to the Institute, was to determine which of those schools were worth while, which should be selected to remain, and which could properly be dropped, I recognized that I must make for myself such a study of selective values as I am outlining here. Among our other departments we had a Library School which in many ways had done admirable work; this was studied among others.

The first thing concerning the Library School that we studied was the curve of students for five years, from 1908 to 1913 (Fig. 4). And as regards the period to be studied, it should be noted here that nowhere else do training and experience as the part of the engineer count more. The analysis of periods which are too long or too short may easily prove not only wasteful but actually misleading. The second problem came in connection with library salaries, tuition, and the disbursements. We found that the library salaries rose considerably, and the disbursements remained about even, while the tuitions fell off materially (Fig. 5).

The total registration of the Institute was 13,201 for five years. Our Library School registration was 95, or 0.7 per cent. The total number of graduates for thirty years' existence of the school was 317. We then studied a comparison

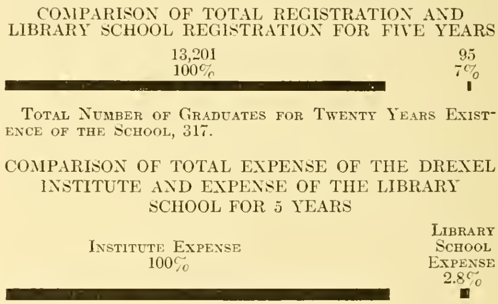



Fig. 6. Comparative Statements of Registration and Expense.

of the total expense of the Drexel Institute and expense of the Library School for five years. The total Library School expense was 2.8 per cent of the total Institute expense (Fig. 6).

We then took up the question of the employment field for the graduate of the Library School. We found in comparing the number of positions and salaries in a selected group of Philadelphia libraries, that there are one hundred and twenty holding positions in selected libraries, drawing from $216 to $600 per annum; thirty-one drawing from $600 to $720 per annum; twenty-seven drawing $900 per annum; and twelve drawing over $900. In five years all the general libraries in Philadelphia took direct from the Library School seven graduates. Total notices on file of vacancies in libraries of the United States for the past five years at salaries of $600 and over, were one hundred and sixty-six (Fig. 7). It should be remembered, of course, that this employment field is for young women graduates, but it must be equally remembered that this is the record for five years. On the basis of the facts shown above, the board decided that the Library School should be given up.

This method is applicable to any business. I have no question that by varying the means of treatment with the necessities of the case, you can determine, to a considerable degree of accuracy, what is right to keep and what is right to eliminate. The educational example used here is chosen as an illustration.

I have already spoken of the question of the time-saving factor in the preparation of reports. The average director or trustee is a busy man. The meetings of the boards of directors or trustees which I have attended in different parts of the country have almost always been brief, a condition which calls for such rapidity and such pointedness of statement, as shall bring conviction to the eye as well as to the ear, and will make possible wise legislative action upon the part of the board. If the proper ends are to be obtained, clarity as well as brevity is essential.

Since 1906, I have been largely interested in the study of engineering reports from the standpoint of clearness. The inadequacy, diffuseness, and obscurity of many of these reports is remarkable. Reports to be read by laymen are either couched in technical language difficult of comprehen-

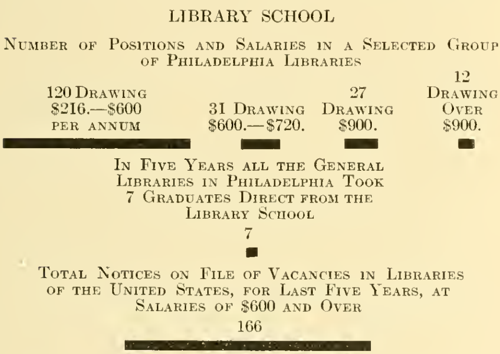



Fig. 7 A Study of Library Positions and Salaries

sion, or so much material is laid before the public that they are commonly unable to come to the final, sharp, clear understanding of what is meant, and such lack of expression is a great handicap to our profession.

### A STUDY IN CLARITY

Fig. 8 shows the summing up of the results accomplished through a study of the type outlined above and through construction on the basis of the study, and illustrates the principle of clarity which it is desired to show.

The results concern the regular delivery of thousands of papers called for daily on the requisitions of clerks. No mention is made of the emergency system of delivery which was constructed in order to care for all such requisitions. The problem here so far as the regular delivery from the file room is concerned resolved itself into four phases:

*a* Diminishing of the time required to fill requisitions. The work done reduced the time in question from five to three hours according to the records made.

*b* Regularity of delivery. The installation of a controlled system of transportation replaced irregularity of delivery with controlled and inspected regularity.

*c* Reduction of irregular messenger service carried on by department clerks. This irregular service was abolished and the whole messenger service carried on by the two boys who had previously done but a part.

*d* Completeness of delivery. This was provided and assured by a complete system of inspection. The entire differences in service noted here was accomplished without increase of working force but actually with a decrease.

### A STUDY IN BREVITY

Brevity is also essential in an engineering report. It is necessary to attack the problem in such a way as to give

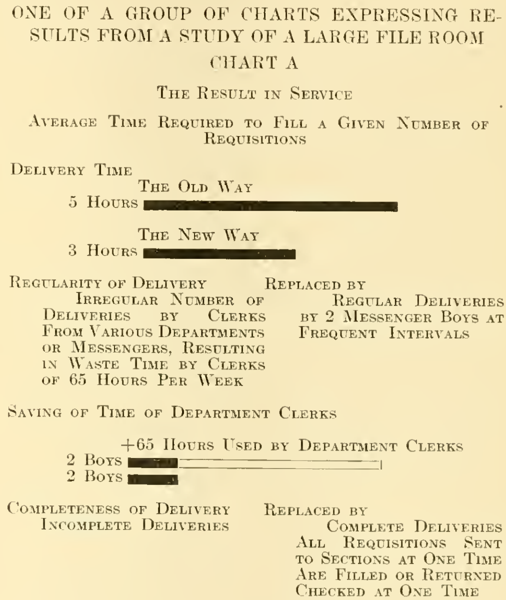



Fig. 8 Plan followed in Summing up the Actual Results

definite and complete information to a limited, definite and complete group. The engineering report is a translation of physical facts to be used in many cases for the information of groups. The group of people for whom that report is written should be considered quite as much in an engineering report as in any other translation of physical facts on paper.

To come to a specific case in Fig. 9, I have constantly found that the question of prices was one of the most difficult things to go into in a short space. I have spent a considerable amount of time in endeavoring to get all price facts about several businesses on a single sheet of paper. The facts were on 34 pages of catalogue when I went to the Drexel Institute, and one would have to read over 34 pages of this catalogue to get all the facts about the different fees and and different items of cost information one would naturally desire. To solve this problem we standardized on fees, and put them all into a single place, and for the sake of clarity stated in all cases three things, the amount, what the student obtained for the amount, and when it was

payable. These are the three questions that are always asked by prospective students and their parents.

REQUIREMENTS OF AN ENGINEER WORKING IN THIS FIELD

There is no question that there is some opposition to any question of engineering study, or especially of any engineering investigation. Most of the present justified feeling against the very word *investigation* has come because of the defects of the investigator. Much of that opposition has come because it was assumed that the engineer was working to investigate or find fault with somebody, instead of working coöperatively with the men in the business to do the most that could be done for the business. Moreover, to make savings of money, service, and time, the coöperative engineering adviser to an executive must be able—

FEES AND STUDENT EXPENSES OF THE DREXEL INSTITUTE

| TUITION | $100. Received in Instruction During Year |
|---|---|
| Paid to Registrar of the Institute | |
| $50. Paid on first registration day. | $50. Paid on second registration day. |
| INSTITUTE FEES | STUDENT EXPENSES |
| Paid to Registrar | Paid elsewhere than to the Institute. |
| SUPPLIES AND LABORATORY EQUIPMENT. | BOOKS AND SUPPLIES. |
| $20. Returned in experience with visible materials used in class during year. Paid to Registrar first registration day. | $25. Received in visible property largely left at end of year. Expenditure made by student at various times during year. |
| STUDENT ACTIVITIES. | MATERIAL FOR APPAREL. |
| $10. Returned in better health and social experience during year. Paid to Registrar first registration day. | Amount largely dependent on student. Received in visible property. Expenditure made by student at various times during the year. |
| DEPOSIT. | INCIDENTAL EXPENSES, LUNCHES, CAR FARE, ETC. |
| $5. Returned in cash if nothing is broken or lost. Paid to Registrar first registration day and covers keys and breakage. | Amount largely dependent on student. Expenditure made by student. |

FIG. 9 CHART INDICATING METHOD OF BRIEF AND COMPREHENSIVE GROUPING OF COST DATA

*a* To distinguish clearly between records which are vital to the future policies of a business and those which are merely historical. The past in industry as a determinant for policies is of value only as it is vitally concerned with the future.

*b* To omit many engineering refinements, that cost much money and lead to a "false and delusive accuracy," as one of my old instructors used to put it; to avoid, so far as possible, in all cases doing work that "costs more than it is worth."

*c* To check his work with the practical needs and limitations of the business, keeping an open and perceptive mind.

*d* To change his methods for the better with the advance of the engineering and industrial art—in short to keep abreast of the "best of the art."

*e* To have a wide acquaintance with those men of his profession and of other professions and callings, who know most of special lines of which he may need to know.

*f* To bring the best that science and industry has yet produced to bear upon the problem before him.

Those are serious requirements to lay down. Yet there is no small number of engineers who I know could meet them all. They can hardly be made materially less, for in work like this the danger of construction turning to destruction in untrained hands, presenting ill digested, wrongly collected, wrongly translated, and wrongly expressed facts, is too great to be readily assumed.

FACTS VERSUS THEORY.

There is another matter which affects very considerably, as I said at first, any problem in engineering investigation, and any problem of expression of engineering facts, and that is the fact that people to-day are looking, it seems to me, for facts properly expressed rather than for legal cases. Again and again in this country we have suffered from one case placed against another, one theory placed against another theory; and I believe that the period is coming more and more when the facts are going to settle problems; but facts alone are not enough. It is only when facts are expressed in such a fashion as to reach the definite audience which it is to reach that facts really gain the day.

On this whole question, it would seem to me that it is of vital importance to the profession to show the industries and institutions of this country the value of such engineering service as I have outlined here, and perhaps also the need to have engineers with training, experience, and the power of expression carry on this work. I have endeavored to express here in concrete form a method of precedure which has been followed by several of my friends, and by myself, in recent years. In my own case, I have been working consciously along this line for the past eight years, during which time I have been concerned with a number of studies of institutions, corporations, and businesses. In each of these, I have endeavored to make of the study a logical whole which should be practical, selective, simple, brief, effective, and properly expressed.

In conclusion, I believe that work of this type offers a great field for the trained and experienced consulting engineer, and that industry in the next few years will realize the need of the consulting engineer as never before. We have for a very long time had to do with the consulting lawyer. I believe the executive of the near future is to be more and more ambidextrous in his counsel, having his lawyer on one hand and his consulting engineer upon the other. We must obey the laws of man, but it is even more necessary to obey the laws of nature, and the consulting engineer is as much needed by the executive, to aid him in the determination and expression of the facts, as his counsel is to tell him what his legal rights are and in what way he can lawfully carry on his work.

# FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

EFFECT OF THE WAR ON FOREIGN PERIODICALS

As has been before pointed out, the events in Europe have seriously affected the amount of engineering material published in the current foreign periodicals. Some of the publications have been entirely discontinued for the present; the others, and among them the leading engineering magazines, have cut down the amount of space in each issue. Then again, many appropriations for research in engineering schools and works of manufacturing companies have been cut down for various reasons, while—and this is the most unfortunate feature of the entire situation—thousands of engineers have been diverted from their regular work to military duties through which many of them have already lost their lives. A vigorous effort is being made, however, to maintain the Foreign Review section of the Engineering Survey at its usual standard.

THIS MONTH'S ARTICLES

In the present issue an article discussing the use of liquid air as an explosive, chiefly for mining and constructural purposes, is abstracted. Its most important features appear to be comparative safety, especially in the case of misfires, and the possibility of manufacturing it in any country where there is a source of power. In the same section is described a new type of two-stage single cylinder compressor of apparently simple and rugged construction.

The "Uto" two-stroke cycle engine, built by a Swiss concern, seems to be also of a very simple design. In addition to that, it has an interesting system of water cooling without water injection into the interior of the cylinder. It has also an interesting and novel form of packing about the main bearings. Some data of tests of the engine operated with crude oil are reported.

The question as to whether ammonia explosions do actually occur in refrigerating plants is carefully considered in a report of an article by G. Cattaneo.

A system of oil separation from water of condensation with particular reference to large power plants and mining plants is described by Mr. Vahle.

From a German periodical is briefly abstracted an article on fireless locomotives, in which, among other things, is contained the statement that such a locomotive used 2½ years fairly continuously in the works of a machine company, cost less than $12.50 in repairs for the entire period.

The present scarcity of copper in Germany called attention to the possibilities of the use of wrought iron in locomotive fire boxes and G. Hammer shows that such a use is also favored by the present conditions of railroad operation and train handling.

The Mellen rod casting machine is described in a paper before the American Institute of Mining Engineers.

The journal of the American Society of Heating and Ventilating Engineers appeared in April in a new form. An article on the measurement of air flow, of considerable interest, is briefly abstracted from it.

From the Memoirs of the College of Engineering, Kyoto Imperial University, is taken an abstract of the main data of tests on the combined bending and torsional strength of cast iron.

Very interesting data of tests on a recent type of chain grate stoker and new methods of baffling Stirling boilers are reported from a paper before the Engineers Society of Western Pennsylvania. From this paper, it appears that a material gain in efficiency is obtained by the use of what the author called the "slow chain" method of firing.

The lateral friction of winding ropes and the magnitude of the angle of maximum friction are discussed in a paper before the Institution of Mining Engineers (London).

Several papers are abstracted from the transactions of the North-East Coast Institution of Engineers and Shipbuilders, such as tests on a Diesel engine in which were used with considerable satisfaction rotary indicator diagrams, and results of substantial interest which have been obtained. The influence of various temperatures on the properties of Admiralty gun metal are discussed by Professors A. Campion and John G. Longbottom, who reported several phenomena bearing on the structure of metals. An interesting paper on the strength of welds made by the acetylene process was presented before the same organization by Professor Campion and W. C. Gray, in which it is again shown that oxy-acetylene welds are not as strong and are less reliable than the unwelded portion of the metal. It was also shown that hammering, while increasing the fatigue resisting properties of the material, may also be productive of brittleness, and that reheating and annealing alone appear to be of little value so far as increasing the fatigue resistance in the welded portion is concerned. Further, that the thicker the plate the less reliable is the weld and the greater the reduction in strength.

From the Journal of the Western Society of Engineers are abstracted two papers, one on the electrification of steam railroads and another (really two papers on the same subject) on wind stress in the frames of office buildings. Particular attention is called to this latter.

## FOREIGN REVIEW

**Air Engineering**

Liquid Air as an Explosive, M. Przyborski

Data on the use of liquid air as an explosive, in particular on the Kowatsch system.

Professor Linde appears to have been the first to introduce successfully an explosive consisting of ground charcoal and liquid air. Since then, Claude and d'Arsonval, in France, have further developed these processes and finally Kowatsch and Baldus, in Germany, have lately worked it out still more fully, partly under the pressure of the present demand for an explosive of exclusively German manufacture.

In order to avoid excessively rapid evaporation of the liquid air, Kowatsch, who uses a cardboard cartridge, introduces first a cartridge with dry carbon into the drill hole separately and without any liquid air, which is put in only just previous to ignition. This process permits reduc-

ing to a minimum the period of evaporation, and also increases the factor of safety of operation.

The cardboard cartridge contains a perforated pipe in which there is a mixture of infusorial earth with oil and asphaltum or lamp black and paraffin, neither of which is explosive in itself. This center pipe contains another cardboard tube over which a third cardboard tube is set, serving as an exhaust pipe for the products of evaporation of liquid air. If several drill holes have to be exploded simultaneously, the electric connections are made accordingly.

The liquid air which has to be used for each hole is kept in a precisely determined quantity in a small bottle, the opening of which is provided with a metal tube and conical nozzle, connected with the central tube of the cartridge. To load the cartridge, all that is necessary is to lift the rear end of the bottle. The liquid air is raised by the pressure of its own products of evaporation and gradually passes into the cartridge. At the instant when the charge is ignited by the electric spark, the liquid air combines with the charge and there follows an explosion of exceptional violence.

Among the advantages of this method of explosion is the fact that, in the first instance, the materials used are not explosive in themselves and the explosive mixture is formed only at the very last moment in the bore hole itself. In the second place, should an explosion be missed, the liquid air will evaporate and the remaining cartridge is perfectly harmless. (*Verwendung von flüssiger Luft als Sprengmittel nach einem neueren Verfahren,* M. Przyborski. *Zeits. für Eis- und Kälte-Industrie,* vol. 7, no. 9, p. 93, March 1915, 2 pp. *d*).

### A Two-Stage Single Cylinder Compressor

Notwithstanding the fact that there are a number of two-stage single cylinder compressors on the market of really good efficiency, new types continue to be introduced and adopted in practice. The author ascribes this to the fact that the two-stage single cylinder compressors introduced so far all suffer from excessive space demand per unit of output and insufficient accessibility.

From this point of view the new compressor (built by Maschinenbau-Aktiengesellschaft Marktredwitz, vorm. Heinr. Rockstroh in Marktredwitz, Bavaria, Germany) described in this article, strikes one as being of very compact design and substantial construction. It is designed in such a manner that it rests on a foundation throughout its length, which tends to eliminate vibration; further, the suction and compression valves on the low pressure side are located on the cover of the low-pressure cylinder which is designed as a valve chamber.

The atmospheric air, after having undergone preliminary compression in the first stage, passes through the compression valve on the low-pressure cylinder cover into an intermediary cooler. Then, through the suction valves of the high pressure stage, it reaches the annular space of the stepped piston, of which the differential area (see Fig. 1A) forms the high pressure cylinder, and here the air undergoes a second stage of compression. As soon as the desired first stage of compression is effected, the compressed air is transferred by the pressure valve to the high pressure side.

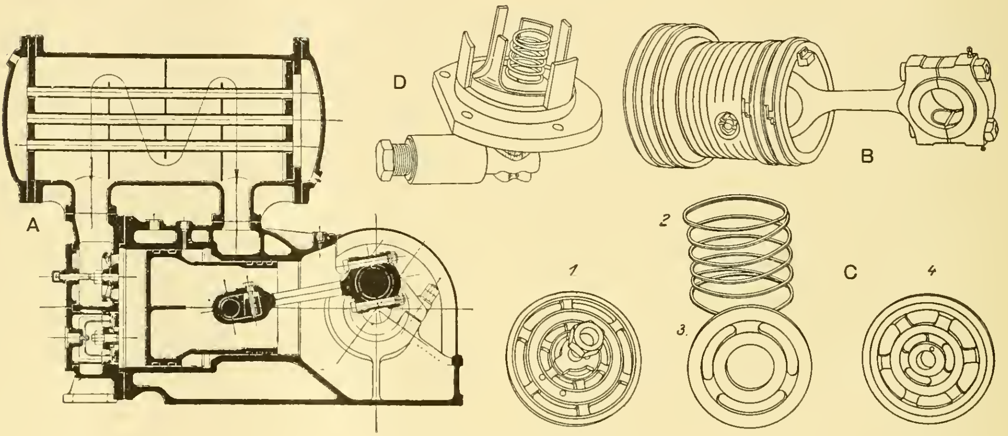
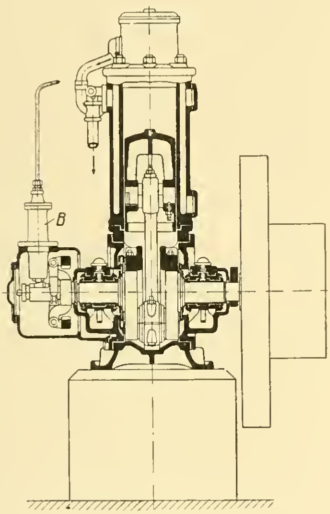


Fig. 1 Two-Stage Single Cylinder Compressor

The piston (Fig. B) is made of gray cast iron. As a two-stage piston, it carries, on both the high pressure and low pressure side, self-tightening packing rings made of alloy cast iron. The pin is set inside the piston and has an extremely hard surface with a soft core which is of considerable advantage from the point of view of wear and mechanical strength. The connecting rod is made of steel and is provided at one end with an adjustable brass bearing for the pin and at the crank pin end with a so-called marine head, the brasses of which are filled with white metal. The shaft is cranked and sits in annular lubricated bearings with white metal bushings. In small compressors, these bearings are made in two parts and equipped with a loose ring. In large units, they are in four parts and equipped with ring lubrication, with self-adjusting rings.

The air is cooled by water, the valve chamber being cooled as well as the working cylinder, and in the intermediary cooler, water cooling is also used. The cooling water passes through the pipes around which moves in countercurrent the air to be cooled, baffles being provided to force the air to move in an indirect path around the pipes.

Fig. C shows the arrangement of the valve gear. Since the flowing air can produce only quite a small pressure on the valve discs, it has been found possible to limit the motion of the valves to the utmost, as a result of which the valve lift could be also maintained quite small. On the other hand, in order to provide a sufficient cross section of flow, ring valves had to be used. Each ring is held against its seat by a spring and the spring (2, Fig. C) is so adjusted that the movement of the valve corresponds exactly to that of the piston. Since the speed of the piston compressor driven by a belt cannot be closely regulated in the present design, the amount of air sucked in is regulated by a separate valve gear, which permits the unloading of the compressor when the air tank is full. If the demand for air increases, the compressor is automatically placed on load again. One design of such a valve gear is shown in Fig. D. It is automatic



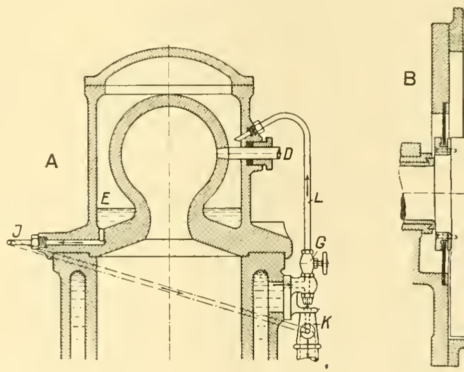




Fig. 2 "Uto" Two-Stroke Cycle Engine

and regulates the air admission by means of a cut-off. As soon as the pressure in the air tank exceeds a certain maximum, the apparatus lifts the suction valve and permits the air taken in to return into the section chamber. When the pressure in the air tank goes down, the suction valve is again released. There is provided a special device, however, to regulate the compressor by hand. In addition to this, further regulation is secured by equipping the flywheel with an electro-magnetic coupling; when the tank is full, the compressor is automatically set at rest while the flywheel is allowed to run.

The original article contains a table showing the efficiencies, outputs and approximate dimensions of the present machine. (*Ein neuer zweistufiger Einzylinder-Kompressor, Der praktische Maschinen-Konstrukteur,* vol. 48, no. 13/14, p. 61, April 8, 1915, 3 pp., 6 figs. *d.*)

**Internal Combustion Engineering**

"Uto" Two-Stroke Cycle Engine

A continuation of an article describing internal combustion motors at the Swiss National Exposition in Bern, in 1914. The present abstract is devoted to the description of the two-cycle "Uto" engine built by the Iron Foundry M. Koch, Zurich, Switzerland.

This engine, built in 4, 10 and 24 h.p. units, appears to be of very simple design. The compression of the scavenging air is effected in the crank case, from which the air flows through slots in the piston and jacket onto the upper end of the cylinder and in this way drives out the residues of combustion through the exhaust ports. The grid valve which admits the air into the crank case has spring steel plates of rectangular cross-section.

The cylinder cover shown in a simplified sketch in Fig. 2A, is semi-spherical designed like a charge cover, but does not have to be maintained in a glowing state in order to cause self-ignition of the charge. In its upper part, the cover is provided with water cooling which protects the material from overheating. This water enters by pipe *L* into the chamber *E*, falling directly on the fuel nozzle *D* and in this way keeps it cool. The water flowing out of *J* is led to the exhaust funnel *K*, designed like an injector. The major part of the cooling water in the cylinder jacket passes through the nozzle into the outflow in order to operate the injector, while the rest of it, because of the suction produced at *J* by the injector, is lifted into the chamber *E* by the pipe *L*. This peculiar method of cooling (and with it the time of ignition) can be regulated, in accordance with the load, by the cock *G*. Of special interest in this connection is the fact that no water is injected into the interior of the cylinder. The fuel oil pump *B* is regulated by a shaft governor which varies the stroke.

In order to make the main bearing fully accessible, the crank space is provided with a patent method of packing (Fig. B) in which a lower membrane is alternately pressed slightly against first one and then the other side of a circular groove. This arrangement permits the equipping of the bearings with ring lubrication and at the same time makes the cover removable.

The author carried out on such a motor a series of brake tests in which he used crude oil of specific gravity 0.87 and obtained the following values:

| | | | |
|---|---|---|---|
| Rev. per min............... | 305 | 306 | 307 |
| Effective brake output, h.p... | 24.9 | 17.25 | 12.35 |
| Fuel per effective h.p.h., g/lb. | 242/.532 | 248/.545 | 273/.600 |

(*Die Verbrennungsmotoren in der gruppe 32 an der Schweiz. Landesausstellung Bern 1914,* Professor P. Ostertag, *Schweizerische Bauzeitung,* vol. 65, no. 15, p. 165, April 10, 1915, 2 pp., 3 figs., article not finished, *d.*)

## Railway Engineering

### Fireless Locomotives

The advantages of the fireless locomotive lie in its unquestionable safety with respect to fire, which makes it extremely convenient for use in factories handling explosive materials and in gas works, as well as in various classes of chemical manufactories. The attendance is extremely simple because of the absence of the usual boiler, with its attendant necessity of watching the fire and water level. Also, since the pressure in the steam container cannot exceed a certain definite amount, it is not necessary to watch constantly the gage and one man can very well take care of even a large fireless locomotive, devoting practically his entire attention to the road. The water container of the fireless locomotive is almost free from scale and the repairs must be very low because of the absence of all the most sensitive parts of an ordinary locomotive boiler, such as the fire box, staybolts, fire tubes, etc.

A fireless locomotive which has been used for 2½ years in the works of the Hannover Machine Company cost only 50 marks ($12.50) in repairs in that period, during which time it was used not only in the plant itself for switching work, but was also several times loaned to other works in the neighborhood. It is considered that a depreciation of 7 to 8 per cent per year is entirely sufficient because of its long life. It has, of course, its disadvantages, and can be used neither for trunk line service, as the author shows by detailed calculation, nor for the handling of heavy loads. Its field is apparently in switching service and hauling loads inside the factory limits.

The article gives in detail the calculation of the water tank as a heat reservoir. A brief bibliography is appended (*Feuerlose Lokomotiven,* G., *Rauch und Staub,* vol. 5, no. 5, p. 73, February 1915, 10 pp., 11 figs. *dp*).

### Wrought Iron in Locomotive Fireboxes, G. Hammer

Discussion of the application of wrought iron in the manufacture of locomotive fireboxes.

Up to the time of the present war, railroads in Germany were very large consumers of copper. A very large amount of secondary equipment, such as door handles, hand rods, etc., as well as all brasses, were made of copper alloys, while fireboxes, stay-bolts and locomotive tubes were made of pure copper. This was due to the fact that experiments with the introduction of wrought iron fireboxes did not turn out satisfactorily some years ago, and it was there found that although the first cost of installation of a copper firebox was several times that of the iron firebox, it paid in the end. In the first instance, because the depreciation of the copper was quite insignificant and the remelted firebox returned practically the original value in metal. In addition to that, copper is easily worked, does not rust, is little subject to burning and easily permits the tightening of joints and stay-bolts.

Of late, however, even in Germany, several circumstances tended to equalize this relation in favor of the wrought iron firebox. The main fact was the rapid increase in size and operating pressures of modern locomotives. This led to a considerable reduction in the life of a copper firebox, first because the great increase in temperature materially reduces the strength of copper and next because its coefficient of expansion is greater than that of iron, so that, in the long fireboxes, there is a greater tendency towards bending, and consequently greater frequency of ruptures.

The conditions of locomotive operation have also changed in favor of the iron firebox which is particularly liable to suffer from rapid and sudden cooling: locomotives are now worked on two and three shift schedules and therefore they are less time out of service. Further, they are now nearly always washed with hot water, which affords better protection than washing with cold water.

The author believes, therefore, that there is a good chance for the introduction of wrought iron fireboxes on locomotives in Germany. (*Ueber die Verwendung von Flusseisen zu Lokomotivfeuerbuchsen,* Gustav Hammer, *Glasers Annalen für Gewerbe und Bauwesen,* vol. 76, no. 907 7, p. 129, April 1, 1915, 2 pp., *g.*)

## Refrigeration Engineering

### Ammonia Explosions in Refrigerating Plants

The author discusses the question as to whether ammonia explosions do actually occur in refrigerating plants.

In particular, he refers to a case of an explosion in a German refrigerating plant, which was ascribed to the decomposition of ammonia in the compressor cylinder and the penetration of the gases into the engine room. This case led to the investigation by the Institute of Physical Chemistry and Electro-chemistry of the Technical High School at Karlsruhe, by S. Schlumberger and W. Piotrowski, who introduced into a bell-shaped glass vessel, 110 mm. (4.33 in.) in diameter, mixtures of ammonia and air in various proportions and ignited them by an electric spark. It was found that a mixture of air with from 16.5 to 26.8 per cent by volume of ammonia violently exploded in the glass vessel, but that with the ammonia content above or below these limits, no explosion took place. Comparative tests with a tube-shaped vessel have given a slower combustion, due probably to the cooling action of the walls, the region of explosibility being limited to from 19 to 25 per cent by volume.

Refrigerating engineers are, however, interested principally in the question whether conditions such as have been shown by this experiment, and which produce explosibility of ammonia and air mixtures, can actually occur in practice. It is hardly likely that under ordinary conditions, 16 to 20 per cent by volume of ammonia can mix with the air, but that may, of course, occur in exceptional cases, for example, when a defect develops in the operation of the machinery, a rupture of a pipe occurs, or something like that. In the case referred to above, a branch pipe broke and allowed ammonia to flow out. The fireman, who was burned about the face and hands, claims that he heard an explosion and saw a flame. As there was a gas burner in the engine room, the assumption naturally was that an explosive mixture of ammonia and air took fire from the open flame.

However, the author doubts this, because the conditions under which the actual explosion occurred did not coincide with the conditions which were present when the tests were carried out. In the latter case, ignition was caused by an electric spark, and, because of the shape of the vessel, prop-

agated with considerable velocity. It is by no means proved that an ignition could likewise occur from an open gas flame and that the combustion in free air would occur in the same manner as in a closed experimental bomb. As a matter of fact, the author doubts that there was any explosion at all in this case, in the sense of a sudden combustion of a mixture of gases, and he supports his contention by reference to another accident where ignition of ammonia by a gas flame appears to be fairly well established. According to a report of the German Slaughterhouse Paper (*Deutsche Schlacht- und Viehhofzeitung*, November 15, 1914, p. 574), in November, 1914, there occurred in the engine and boiler room of the Municipal Slaughterhouse, at Elbing, a fire due to a rupture on a compressor and ignition of the escaping ammonia by an open gas lamp. It appears that in this case a screw on the compressor piston worked loose and fell between the piston and cylinder cover so that during the return stroke of the piston the cover was fractured. No explosion occurred, but there was a strong fire, which destroyed the roof of the house.

Mr. A. Behr, in a Report to the Sixteenth Annual Meeting of the Association of German Inspection Engineers (Verhandlungen der 16. Hauptversammlung des Vereins Deutscher Revisions-Ingenieure), read a paper on the "Decomposition of Ammonia in Ice Machines," where he mentions a grave accident in the brewery of the Hildesheim Brewery Company, in which case an ammonia compressor was started with the exit valve in the pressure piping closed. As a result, the cylinder was brown up by the increasing pressure. Immediately thereafter, the entire engine room, which was lighted by gas, was enveloped in a sheet of flame. In another case, in a Berlin brewery, rapid ignition took place when a fire was brought near an open ammonia compressor. According to the opinion of Mr. Behr, this accident was due not to the combustion of ammonia and air mixture, but to the ignition of hydrogen which formed in the engine through the decomposition of ammonia, which decomposition, in its turn, was due to rise of pressure and temperature of ammonia caused by starting the compressor with a closed pressure valve.

That this decomposition does take place was shown by the experiments of Doctor Mohr, who has found in three instances a high content of free hydrogen and nitrogen in experimental compressors. For practical purposes it would be desirable to carry out a theoretical and experimental investigation which would show whether decomposition of ammonia actually takes place, and if so, how it can be prevented. (*Zur Frage der Ammoniakexplosionen*, G. Cattaneo, *Zeits. für die gesamte Kälte-Industrie*, vol. 22, no. 1, p. 3, January 1915, 2 pp., *pe*).

**Steam Engineering**

Oil Separation from Water of Condensation

The article describes a method of separating oil from water of condensation, such as is applied in Germany in mine plants and large engine houses.

Where there is a large number of engines, the author recommends leading the water of condensation to some deep well (Figs. 3A and B), arranged in such a manner that it is divided by the walls *d* into three large compartments, *a*, *b* and *c*. Into one of these compartments the water of condensation, rich in oil, is allowed to flow, and is then led through the several pipes *e* from the deepest part of the well into the second compartment, whence it passes into the third compartment, and is finally delivered to where it belongs by the centrifugal pump *f*, having its suction point at the deepest part of the well.

Since the water of condensation is still so hot that it cannot be taken up by the pump with a high suction head, the pump is located in the shaft *g* close to the collector well in such a manner that it is below the water level of the third compartment. In order that the third compartment would not be drained if its inflow should happen to be lower than the delivery of the pump, there is provided in the suction piping a throttle valve *h*, with float *i*, maintaining the water level in that section always at the same height. The third section is further provided with an outflow port *k* (leading into the sewers), the purpose of which is to prevent the well from being flooded in case of the pump stalling, or of

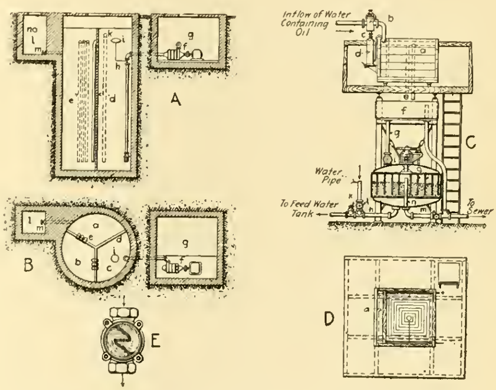



Fig. 3 Plant for Separation of Oil from Water of Condensation

excessive influx of water. This outflow is located at a point much higher than the suction piping, and is connected by a pipe with the bottom of the well, so that all outflow water should be as free from oil as possible. To permit of the cutting out of the entire plant for purposes of cleaning or repairs, the water of condensation, rich in oil, coming from the various sources, is led into a small collector well *l*, located in front of the first section; this well way be cut off from the first section of the tripartite well by means of a valve *m*. When this valve is closed, the water is discharged directly into the sewer pipe by an exit port *n*, located at the higher level.

When the water of condensation is admitted to the well, the oil in it is in a state of either drops or emulsion. In the well, when the water is in a state of rest, the oil in drops separates because of the different specific gravity, and can be easily collected on the surface of the water. This oil is pure because of the heavier impurities having settled down to the bottom of the well, and can, therefore, be again used for cylinder lubrication. If, however, the water of condensation is intended for use as boiler feed water, it must be freed also from the oil in the state of emulsion, and this can be done electrolytically, for example, by means of the apparatus shown in Figs. C and D (Reubold electrolytic oil separator).

The water, rich in oil, is supplied by a centrifugal pump, above referred to. It first passes through chamber *a*, where it is led between the worm-shaped electrodes, the separation of the oil taking place under the action of the electric current. Since, however, the water of condensation, apart from the oil it contains, is nearly chemically pure, it is a very bad conductor of electricity, and the device would not work at all unless this resistance were previously decreased by some means. In this case this is done by the addition of a solution of soda. In the supply piping is built in a vessel *b*, out of which, through a throttling valve *c*, the soda and water for this solution are supplied to the tank *d*. After the water of condensation has passed through between the electroids, it flows, together with the oil, which is now separated in the form of flakes, through pipe *e* into the collector *f*, provided with an overflow, and thence through pipe *g* into the gravel filter. Here all the oil particles are separated from it, and the pure water flows through pipe *h* into the reserve tank.

From time to time, in accordance with the load which the oil separating installation carries, it is necessary to wash the gravel in the filter. To do this, valves *i* and *k* are closed and valves *l* and *m* are opened. Pure water flows in through valve *l*, forces for itself a path through the gravel and floats the oil particles to the surface, whence, through stand pipe *n*, they pass into the discharge piping. In order to increase the efficiency of washing of the gravel, the contact device *o* is rotated by a hand crank in smaller installations and by an electric motor in larger sizes.

For 1 cbm. (35.3 cu. ft.) per hour, approximately 0.2 kw. direct current are necessary, which means that at the price of 2 pfennigs (½ cent) per kw. hr., the cost of electric purification amounts to less than ½ pfennig per cbm. The plant works entirely automatically, and the attendance is limited to cleaning the filter at regular intervals and taking off the oil collected from electro-deposited emulsion on the surface of the water in the chamber *a*. It is advisable to locate the plant at such an elevation that the water of condensation coming from the gravel filter will flow into a feed water tank located at an equally high elevation. This arrangement is particularly advisable where centrifugal pumps are used for supplying boiler feed water, because purified water is still quite hot. Such pumps work at their best where the water is supplied to them by gravity.

In a different connection, the same article describes what the author calls a device for inspecting steam traps. This device, shown in Fig. E, is built in such a manner that the water or steam, flowing under the glass, is forced to change its direction twice, which enables one to see clearly through the glass, whether it is water or steam that is flowing, or whether there is no flow at all. (*Gewinnung von öl und ölfreiem Kondensat aus Abdampf*, M. Vahle, *Glückauf*, vol. 51, no. 17, p. 409, April 24, 1915, 4 pp., 6 figs. *d*).

## ENGINEERING SOCIETIES

### AMERICAN INSTITUTE OF MINING ENGINEERS

*Bulletin, no. 101, May 1915, New York City*



The Mellen Rod-Casting Machine, R. C. Patterson, Jr.

Description of the Mellen rod-casting machine, introduced by Grenville Mellen to take the place of the present system of producing rods of zinc, brass, copper and aluminum.

The new process consists in the production of cast rods in one operation in a small continuous casting machine. The hot liquid metal is transferred from the molding crucibles directly into an endless chain of molding blocks in the machine, where solidification takes place and the rod comes out continuously in solid form from one end as long as the molten metal is supplied. The operation of these small blocks, so as to produce a solid rod of uniform structure, constitutes an important part of the process.

The article describes in detail the machine shown in Fig. 4. It is 12 ft. in height over all, 2 by 3 ft. in horizontal

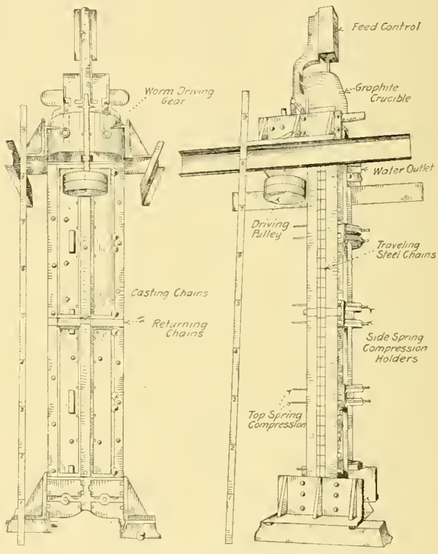



Fig. 4 Mellen Rod-Casting Machine

cross sectional area and weighs 6000 lb. A cast iron frame work holds in position two endless chains of molding blocks, which are made in sections and joined in center alignment. The mold orifice is made up of these mold sections into which the liquid metal flows. The accuracy of alignment, requisite for the production of a perfect rod in the groove formed by these sections, is secured by careful machine work and by building the four ways, down which the alignment takes place, so that two of the sides are fixed permanently while the opposite sides are held to their position by spring pressure. The guides carrying the molds while in casting position are water-cooled square tubes. The length of the machine is indeterminate; a certain amount of both time and cooling surface is required to solidify the metal in the mold and one may use either a long molding chain and run it fast or a shorter chain and run it slowly. The machines may be either vertical or horizontal.

The flow of metal into the machine is controlled by an electrically operated automatic device which adjusts the feed

to the speed at which the machine is operated. If for any reason the machine should stop, the flow of metal would also be automatically shut off. If any foreign material clogs the chain, a safety pin is thrown to protect the mechanism from injury. The rods are delivered from the machine immediately to the die of a bull block, which turns them down to suit particular orders. The advantages of the machine are simplification of manufacture, elimination of loss from oxide scaling during the heating and rolling, and elimination of danger to human life—the latter because the apparatus is completely enclosed and the operator is protected from injury.

The article describes also a continuous casting machine for making rods of lead and soft metal alloys 1/4 in. and upward in diameter. The author states that the machine's operating cost is less than 30 cents per ton of molten metal cast into the form of rods (7 pp., 4 figs. *d*).

## AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

*Journal, vol. 21, no. 1, April 1915, New York City*

Measurement of Air Flow, Arthur K. Ohmes (abstracted)
Pipe System for Water Heating, Professor F. E. Giesecke
Apparatus for the Study of Heat Radiation, Professor J. D. Hoffman

### Measurement of Air Flow, Arthur K. Ohmes

Description of various apparatus used for the measurement of air flow. Discussion of their advantages and disadvantages and field of application.

The author divides all instruments for the measuring of the flow of air into seven classes, which he considers preferable to the division into so-called volumetric and pressure measuring instruments because of the intimate relation existing on some instruments between volumetric and pressure conditions.

The precision of measurements in heating and ventilating has notably increased during the last two decades. Fifteen years ago engineers were satisfied to be able to read a column of water accurately within one-tenth of an inch. Five years ago, one-hundredth of an inch was considered an accomplishment; while today instruments are available with which one-thousandth of an inch of water can be measured. The same applies to air measurements. Ten years ago, measuring an air current at a velocity as low as 1 ft. per second was approximately the limit, whereas today a current of air of less than one-tenth of a foot per second can be measured with fair accuracy. The author believes, however, that the limit of exactness in this field of measurement has by no means been reached.

Various types of meters, anemometers, Pitot tubes and devices for measurement by adding heat to the air are described, as well as long distance and centralized air measurement gages, and the micromanometer. These descriptions are not suitable for abstracting. The common fly-wheel anemometer is not suitable for air velocities below 2 ft. per second because the work done by the air to overcome friction is, at low velocities, lost for measuring the air current itself. If, however, the frictional losses in measuring air current are compensated for (as in the apparatus described by the author), an anemometer can be used for the lowest air velocities.

As regards Pitot tubes, the author believes that the ultimate Pitot tube that should be accepted as a standard the world over need not be one with a correction factor of unity (like the Prandtl tube), and may have any, or even a large, correction factor, if constant, for any and all velocities, provided the slight deflections of the tube will not vary the results for velocity and static pressures. He believes, however, that except when both great accuracy and integrity prevail in making the test (as in laboratory or small apparatus factory tests), it is difficult to expect much consistency in air measurements with Pitot tubes. The author strongly insists that in any case, in order to secure uniform results, the most accurate instruments are necessary, and that the greatest care and integrity of purpose is required. (23 pp., 26 figs. *d*).

## COLLEGE OF ENGINEERING, KYOTO IMPERIAL UNIVERSITY

*Memoirs, vol. 1, no. 2, February 1915. Kyoto, Japan.*

Tests on the Combined Bending and Torsional Strength of Cast Iron, Tsuruzo Matsumura and Genjiro Hamabe (abstract)
Beiträge zur Theorie der Elastizität gekrümmter stabformiger Körper, Tsuruzo Matsumura.

### Tests on the Combined Bending and Torsional Strength of Cast Iron. Tsuruzo Matsumura and Genjiro Hamabe

The paper investigates the elastic behavior of cast iron under combined bending and torsional stresses.

Recent experiments on elastic failure of mild and harder steels show results not in close conformity with the principal stress theory of Rankin or the principal stress theory of St. Vénant. They rather support the hypothesis proposed by Mohr in 1900, which may be stated as follows: "Elastic failure of ductile material or the breaking of a brittle material takes place when the shearing stress, acting at the point along a certain plane, attains a limiting value which is a function of the normal stress at that point." As regards the combined strength of a brittle material like cast iron, little is known, which was the incentive for the experiments carried out by the writers.

The testing machine was designed in conformance with the principle of Croker's testing machine. The test piece was made of the form and dimensions shown in Fig. 5A. The diameter $d$ was taken as 11/16 in. for ordinary cast iron and 5/8 in. for high grade cast iron. All the test pieces in a single series of tests were cast in one charge. Fig. B shows the method of molding for Series 1 and 2 and Fig. C, that for Series 3 and 4. In the tests, the writers determined the bending moment and torsional moment for various pieces, calculated the constants and the bending strength for each series of cast iron by the method of least squares, and gave a series of curves of which only Fig. D is here reproduced, as representing the law of combined strength corresponding to the equation

$$M_o = (1-A)M + A\sqrt{M^2 + T^2}$$

where $M$ is the moment of bending, $T$ the torsional moment, $A$ a constant and $M_o$ the equivalent bending moment; that is $M_o = \frac{\pi}{32} d^3 K$ if $d$ is the diameter of the rod subjected to the combined action and $K$, the bending strength (elastic bending strength for a ductile material). It was found that the St. Vénant theory applies to cast iron in the most satisfactory manner. A plate is given showing the forms of fracture for one of the series of tests. Attention is called to the

fact that as the ultimate torsional moment is greater, the section of fracture is more inclined toward the plane normal to the rod axis (8 pp., 10 figs. *e*).

## ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

*Proceedings, vol. 31, no. 1, February 1915, Pittsburg, Pa.*



Tests on a Recent Type of Chain Grate Stoker and New Method of Baffling Stirling Boilers, John A. Hunter

The installation (Vandergrift Works of the American Sheet & Tin Plate Company) on which these tests have been made, consists of seven class M-22 Stirling boilers nominally rated at 600 h.p., containing 6032 sq. ft. of water heating surface and 396 sq. ft. of super heating surface. For draft it has an individual unlined steel stack 72 in. in diameter and 150 ft. high above the breeching. Each boiler is provided with one type "L" Green Engineering Company stoker, 10 ft. 6 in. wide by 12 ft. long, containing 126 sq. ft. of chain surface, the initial tests having been undertaken to determine if the guarantees made for the stokers could be met. During these tests, the baffles were arranged as shown in dotted lines on the drawing Fig. 6A and the openings at the end of the baffles were according to the dimensions in the circle. In place of the pressure water-back there was a single pipe supplied with low pressure water. These tests indicated that the efficiencies obtained were below the guarantee.

To meet this condition, the baffles were changed as shown in solid lines on the drawing and a special water-back was installed with two separate water boxes placed one directly over the other and each one connected to the mud drum and front steam drum, thereby insuring positive circulation throughout the box. All tests were conducted according to the Code of The American Society of Mechanical Engineers (the procedure is fully described in the original paper).

For tests numbers 180-182, the gate was about $6\frac{3}{4}$ in. above the pusher and in tests 183-189 the gate was about $7\frac{1}{2}$ inches above the pusher; after test 182 a change was made in the manner of operating the stoker designated as the "slow-chain" method of operation to distinguish it from the old method of "fast-chain." The slow-chain operation was used on the rest of the tests. In diagram B, the area under the dotted lines shows the character of the fuel bed with the fast-chain method of operation. The depth of the fuel bed is about the same over the entire grate except near the water-back, where it is piled up. The character of the fuel bed with the slow-chain method of operation is shown by the solid line on the diagram. Here the fuel bed is quite deep on the front part of the stoker and gradually thins out until it is about the same depth as the fuel bed of the fast-chain operation, with the exception of a point about 3 ft. ahead of the water-back, where it is also piled up.

With the fast-chain method, the distillation of the volatile gas of the coal takes place very rapidly and a large portion of it passes off in the flue gases and is burned, which is evidenced by the amount of smoke observed. The coal does not remain on the grate a sufficient length of time to have its carbon content completely burned. With the slow-chain method, the distillation of the volatile gas takes place quite slowly. All this gas is driven off by the time the thin portion of the fire is reached, and as there was practically no smoke except at very low ratings, it is thought that practically all the volatile gas is burned. The thin portion of the fire allows an excess of air to be drawn through the fuel bed at this point, which completes the combustion of the carbon.

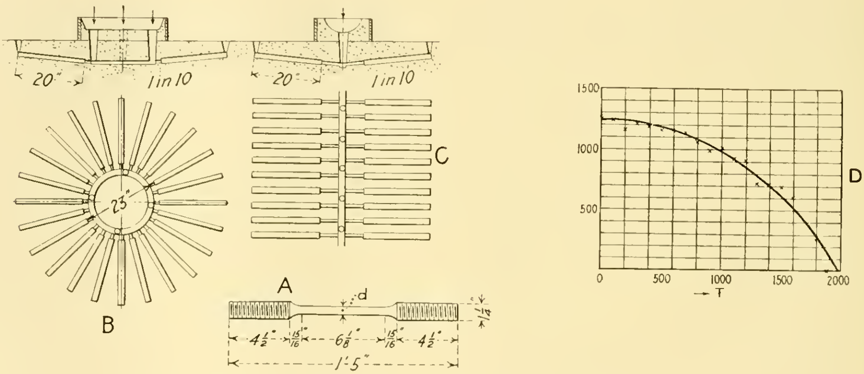



Fig. 5 Methods of Molding Test-Pieces for Testing the Strength of Cast Iron

A number of tables are given showing the results of the tests. From these tables, it is seen that efficiencies from 67.7 to 79.8 per cent and capacities from 74 to 195 per cent of rating were obtained. In regard to the percentage of combustibles in ash, it varies with fast-chain firing from 33 to over 44 per cent, while with slow-chain, it was maintained around 23 per cent and in one case went as low as 17.86 per cent. The flue gas temperatures with fast drive vary from 520 to 617 deg. and with slow drive from 417 to 550 deg., but excluding two cases of exceptionally high flue gas temperature, the average for the slow-chain method was around 450 deg., or apparently very much lower than with the fast-chain. The loss due to radiation varied from 2.55 to 5.70 per cent, with an average of 400 per cent for all the tests.

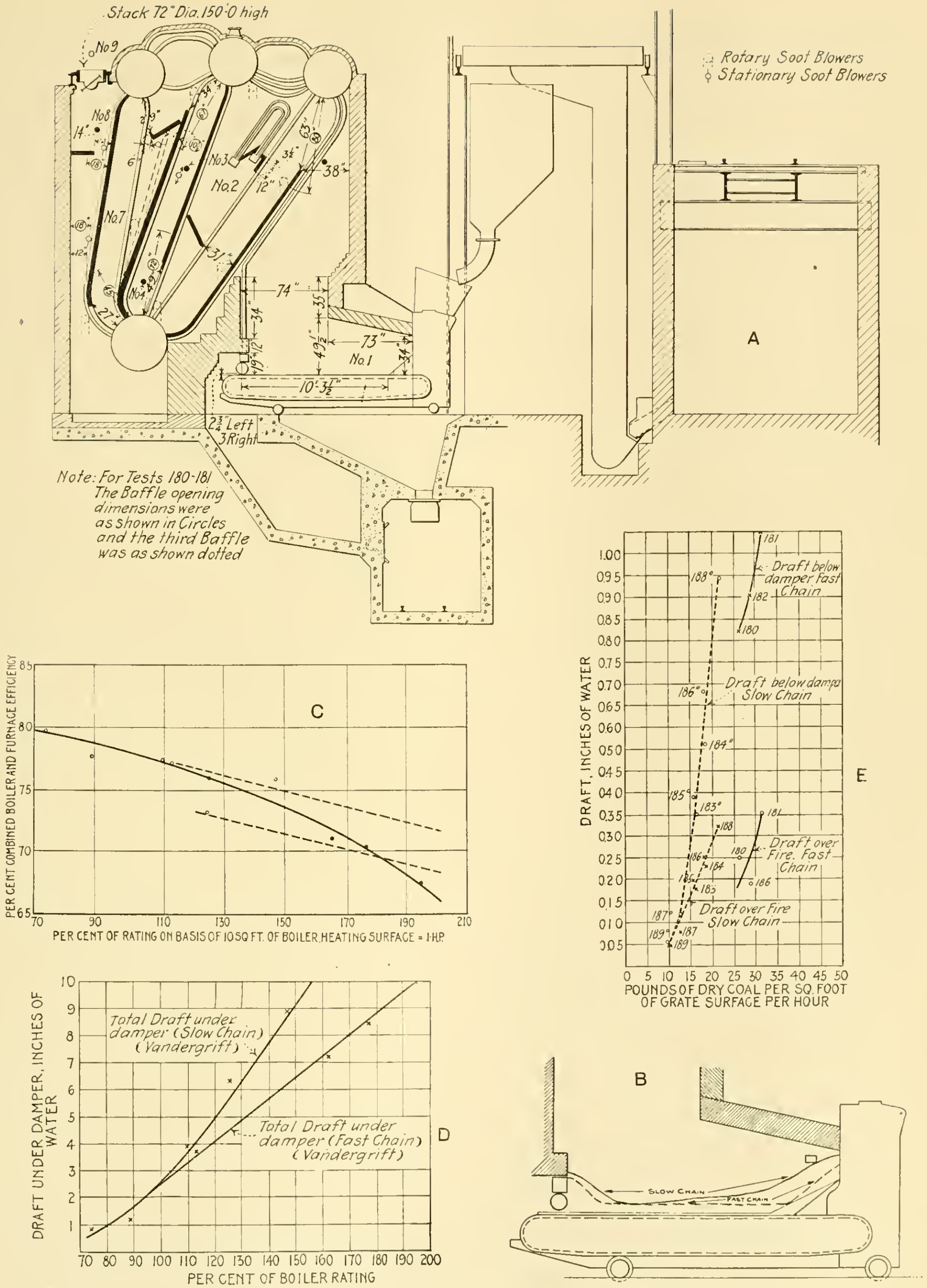



Fig. 6 New Method of Baffling Stirling Boilers; "Slow Chain" Method of Firing

The uniformity of these results would tend to indicate that no appreciable error has been made in taking the data.

Curve Fig. C shows the relation between the percentage of boiler rating and combined boiler and furnace efficiencies. The curve shown in solid lines refers to the actual efficiencies obtained from all the tests. The points below 150 per cent capacity are for the tests run with slow-chain method and points above 150 per cent capacity are for the fast-chain method, about 150 per cent of rating capacity being the maximum which can be obtained from this boiler with the slow-chain method of operation; so that when capacities above 150 per cent were desired, it was necessary to increase the chain speed and change the operation to approach the fast-chain method.

By taking indicator diagrams from the engine driving the stoker, it was found that it required an average of 0.72 i.h.p. to operate the stoker. Allowing 80 lb. of steam per horse power hour, the following percentages of steam genearted are required for the operation of the stoker: at 100 per cent rating, 0.35 per cent; at 150 per cent rating, 0.23 per cent; at 200 per cent rating, 0.17 per cent. Quantities so small that for all practical purposes the efficiencies obtained can be considered as net efficiencies.

In the discussion which followed, D. S. Jacobus stated that, in his opinion, the striking feature of the tests is the gain in efficiency due to the use of the slow-chain method as compared with the fast-chain. The heat balances show that this was due to a more perfect combustion and better ash. The lesser amount of smoke produced with the slow-chain method is also an item favoring efficiency. It is usually best to make an investigation of the method of operating furnaces rather than perfunctory tests and to depart considerably from what may be considered standard practice, in order to get the results. The speaker was present at one of the tests and was impressed with the great care which was exercised to secure accurate results.

John Wolff, of the Cleveland Electric Illuminating Company, stated that for some months past the station of his company was operating in a somewhat similar manner. It was found that for ordinary everyday operation, fixed conditions of fuel feed could be established and required no change from one month's end to the other, and that with these conditions established, it was possible to take care of momentary variations of load by simply manipulating the dampers. For peak work the speed of the chain only is increased, which is done by changing the chain feed from two to three teeth of the ratchet. With these manipulations a uniform steam pressure could be maintained as well as water level with little or no fluctuation, requiring few adjustments of the feed valve. One of the most important advantages of such a system is the extreme confidence which the operators feel in their ability to meet and handle all situations.

W. E. Snyder, of the American Steel and Wire Company, Pittsburgh, called attention to the fact that the determination of the efficiencies of boiler and grate depends on the knowledge of the correct heating values of the coal, as a high over-all efficiency may be obtained by ascribing to the coal a low heating value and showing the heat lost up the stack and to the ashpit as less than it actually was. From this point of view, the speaker, while believing that there may be a wide variation in the heating value of the coal obtained from the same mine, calls attention to the fact that as shown by the paper, the heating value of the dry coal obtained from the same mine varied from 12,900 to 13,616 B.t.u. per pound. He recalculated the results in one of the tables, using the heating value of the coal given and the ash by analyses of the coal, and found that the average heating value per pound of combustible is 15,120 B.t.u. with a minimum of 1.1 per cent below the average and a maximum of $^2/_3$ of 1 per cent above the average, giving a close and consistent agreement among the samples. With the ash in the coal as determined by analyses, it can be used to check the quantity of refuse from the ashpit and its analysis. The author prepared a table by taking the total percentage of ash refuse that went to the ashpit and multiplying it by the percentage of incombustible matter which it contained. This gave a new percentage, which is the incombustible matter in the coal as determined by the analyses of the refuse from the ashpit. On the whole, he found that the ash in dry coal as determined by analysis of ashes from the ashpit is equal to 11.10 per cent and the average of the ash as determined by chemical analysis of the coal is 11.70 per cent, or a difference of 0.6 of one per cent, this difference being in the right direction, as the coal analysis should give a slightly higher ash because of some of the fine ash being carried out from the furnace over into the boiler and not being taken out of the ashpit. While in this manner a close constant agreement of data of ash content is secured, it is not possible to have an equally satisfactory check on the quantity of heat lost up the stack because the nature of the data does not permit it.

M. Alpern, of the American Engineering Company, Philadelphia, believes that an improvement can be expected in boiler maintenance through the elimination of the Stirling arch. The speaker referred to tests conducted at the Detroit plant on a five pass specially baffled Stirling boiler. Fig. D illustrates the total draft in the case of the Vandergrift specially baffled boiler with slow-chain and fast-chain method of operation. From these curves, it would appear that the limit of the available draft with the slow-chain operation was reached at approximately 155 per cent of rating, whereas the fast-chain method obtained a considerable higher rating. The Vandergrift boilers were operated at 125 lb. pressure. Additional data on the same boilers were supplied by T. A. Marsh of the Green Engineering Company of Chicago. The coal used at Vandergrift contained on an average 1000 B.t.u. less per pound than the coal used in Detroit and nevertheless the percentage of combustible in the ash at Vandergrift during the slow-chain tests was lower than that of the well known Edison plant at Detroit, although the furnace at Vandergrift is not as large as the one at Detroit and probably the combustion of the hydrocarbons was not as complete. On the other hand, the heat loss, due to radiation, was certainly higher at Vandergrift than at Detroit, due to the difference in the size of the units. T. A. Marsh has further prepared curves (Fig. E) showing the combustion rates per unit of draft obtained with the fast-chain method as compared with the slow-chain method. With the fast-chain method the combustion rate of 30 lb. of dry coal per sq. ft. of grate surface per hour, using a furnace draft of 0.30 in. water column; with the slow-chain method, the same draft was used for a combustion rate of only 21 lb., with the draft below the damper in both cases 0.90 in.

The speaker summarized the differences in results obtained

by the slow-chain method as follows: *a.* For the same combustion rate, a chain speed of less than one-half; *b.* A furnace draft of much greater intensity; *c.* Lower flue gas temperatures; *d.* Lower percentage of combustible in the ash; *e.* Higher percentage of $Co_2$; *f.* Practical elimination of smoke; *g.* Increased capacity due to increased efficiency at a given combustion.

Certain objections to the views and methods of Mr. Hunter were expressed by A. A. Straub, of the Duquesne Light Company, Pittsburgh. He considered the efficiencies obtained too high, and expressed the opinion that in this case efficiency has been obtained at the expense of flexibility in operation. He gave a diagram showing that the efficiencies decrease rapidly with increased percentage of rating contrary to the case in the Delray tests with under-fed stoker, where higher ratings were obtained.

J. E. Bell pointed out that the baffle at Vandergrift was not designed to produce a minimum draft loss or to absorb the maximum amount of heat from the gases; and it would appear that in this particular it answers the purpose. If a greater capacity should be required from a boiler with this baffle, the draft available at the damper must be increased by an amount corresponding to the rule that, at higher ratings, the draft loss is almost directly proportional to the square of the capacity, and to that should be further added the amount necessary to burn the additional coal.

In answer to questions, the author stated that no particular effort was made to prevent radiation, the brick work of the boiler not being covered with heat insulating material. As regards the efficiency curves shown by A. A. Straub, comparing data obtained at the Vandergrift tests with those obtained from tests made of the boilers in the Delray station of the Detroit Edison Company, the author pointed out that efficiencies obtained from chain grate stokers ought not to be compared with those from forced blast underfeed stokers without making a correction for the power required to operate the stokers. To this he adds the Table 1, showing the comparative efficiencies between the two sets of tests, the net efficiency with the slow-chain operation being slightly higher than those of the Delray tests, although it is true also that in some cases part of the steam which is required for the operation of the stokers can be recovered in the feed water heater.

The subject of determining the moisture in the coal brought up an extensive and interesting discussion, which cannot be reported here because of lack of space. (55 pp., 15 figs. *eA*).

## INSTITUTION OF MECHANICAL ENGINEERS

*Journal, April 1915, London*

Convertible Combustion Engines, discussion
Graphical Method of Finding Inertia Forces, Wm. J. Duncan (abstracted)
The Chemical and Mechanical Relations of Iron, Cobalt and Carbon, J. O. Arnold and A. A. Read

### A Graphical Method of Finding Inertia Forces, William J. Duncan

The paper develops a graphical process for the solution of certain problems in the dynamics of machines. In it the fundamental element is the determination of the point called the acceleration center, and the author shows that this can be ordinarily done when the circle of inflections has been constructed. This latter is a curve representing the locus of points in a body whose respective velocities and accelerations are parallel. It is so named because any point on it is momentarily at a point of inflection on its path. The locus of points, whose respective velocities and accelerations are perpendicular, may be called, according to the author, the circle of zero tangential acceleration. The author shows that a knowledge of the circle of inflections is of very material help in the determination of the acceleration center, and further shows how, having given the circle of inflections from which it can be determined and the direction of the acceleration of one point, the acceleration center can be constructed. In this way, he proves that the accelerations of all points in magnitude and direction can be found when the circle of inflections, the direction of the acceleration of one point and the magnitude of the acceleration of another point are known. He then proceeds to the discussion of the application of his constructions to the dynamics of machines;

TABLE 1 COMPARATIVE EFFICIENCIES OBTAINED IN THE VANDERGRIFT AND DELRAY TESTS

| Percent Rating Developed | Vandergrift Tests Slow-Chain Method | | Delray Tests | |
|---|---|---|---|---|
| | Gross Efficiency | Net Efficiency | Gross Efficiency | Net Efficiency |
| 74 | 79.82 | 79.4 | 80.2 | 77.7 |
| 110 | 77.45 | 77.1 | 79.0 | 76.4 |
| 126 | 76.00 | 75.7 | 78.5 | 75.8 |
| 148 | 75.86 | 75.6 | 77.8 | 75.0 |

for example, theory of a link of a four part mechanism; oscillating cylinder mechanism, such as an oscillation engine, accelerating force on the piston and piston rod; determination of the inertia forces in a Gnome engine, etc. Stricter mathematical proofs of the statements and constructions proposed in the body of the paper are given in an appendix (30 pp., 25 figs. *tm*).

## INSTITUTION OF MINING ENGINEERS

*Transactions, vol. 49, part 1, March 1915. London*

Power Costs, William B. Woodhouse
The Absorption of Oxygen by Coal, Part VII, J. Ivon Graham
The Lateral Friction of Winding Ropes, H. W. G. Halbaum (abstracted)
Winding Engine Signals, Wilfrid H. Davis
The Nature of Explosions, Professor Harold B. Dixon

### The Lateral Friction of Winding Ropes, H. W. G. Halbaum

In this article is discussed the question of lateral friction of winding ropes, in particular for the case of the ordinary wide drum. It is claimed to be merely an attempt to state the problem in the simplest terms.

$A$ is the angle of maximum friction. When the rope between the pulley and the drum lies in the same vertical plane as that of the pulley, there is no lateral friction. This line of no friction is called by the author, the "center-line." When the rope has diverged to its utmost limit from the center-line, it makes an angle $A$ with that line, called the *angle of maximum friction.* Under no circumstances need it exceed 3 deg., and in many cases 1 deg. During the wind-

ing, the angle of friction varies from zero to $A$, but it is the maximum angle only that must be taken into account, since it is invariably the same portions of rope which suffer from its influence in each successive wind.

Several ways have been proposed to reduce the angle $A$, for example, by reducing the width of the drum so that the rope is obliged to coil upon itself during the latter half of the wind. $A$ may also be kept at its lowest possible value by so attaching the rope to the drum that it lies truly on the center-line when the cage is at "meetings" or half-depth. In some cases there may be a little difficulty in the centering of the rope at the middle point of the winding, but this difficulty might easily be overcome by fitting the winding drum, or at any rate the lower portion of the wind, with a spiral screw-thread, which would guide the rope in the path required to insure its centering itself at the middle point of the wind. This spiral screw-thread is not grooved, however.

The author develops the following formula, for which it is assumed that the normal diameter of the rope is $d$ inches, the width of the drum employed by each coil of rope on the drum is 1.1 $d$ inches, the rope being centered at "meetings":

$$A = \frac{10H}{RL}$$

where $H$ is the height of the banking-level above the onsetting-level, $L$ the length of rope extending from the pulley to the drum and $R$ the ratio of the drum diameter to the normal diameter of the rope (in practice from 110 to 150); $H$ and $L$ may be taken in any units, but both must be in *similar* units. If it be ordered that $A$ shall not exceed a given predetermined numerical value, the winding engine must either be placed at such a distance from the pit that $L = \frac{10H}{AR}$ or the drum must be of such a diameter that $R = \frac{10H}{AL}$, that is to say, if $D$ is the diameter of drum, and $d$ diameter of rope (both in similar units), the following formula must be taken: $D = d \cdot \frac{10H}{AL}$

The above formula shows that since $H$ cannot be altered for a given mine, $A$ can be reduced only by increasing $L$ or $R$ or both. $L$ may legitimately be extended to 50 yd. (there is an objection to making it too long because many managers prefer the engineman to have a clear view of the banking operations and cages), and then a reasonable value of $R$ will reduce the angle $A$ to about 1.5 deg., even in the case of the deepest British coal mine, always provided that the ropes are so adjusted as to center themselves at "meetings." In the case of shallow mines, the lateral friction should be quite a negligible quantity.

The author, among other things, comes to the following conclusions: Other things being equal, the lateral friction varies as the square of the angle $A$ of friction; other things being equal, the destructive character of the lateral friction varies with the roughness of the rope; hence, ropes of the flattened-strand and locked-coil type suffer less than ropes of the ordinary type, because the coefficient of friction is less. Lubrication reduces lateral friction.

In the discussion which followed numerous objections were made to the statements of the above speaker.

Hugh Bramwell, who lately installed at the Cwm Colliery, Pont-y-pridd, Wales, a hoist to raise 12 tons of coal per wind, from a depth of 800 yd., stated that the maximum permissible lateral angle should be limited to 2 deg. as an outside figure. In a case within his knowledge, where 2 deg. had been exceeded, the lateral wear on the rope (locked-coil) was material. In the Cwm Colliery installation, the rope was allowed to overlap, this being done to reduce the size of the drum. In that case, the choice lay between a 30 ft. diameter drum weighing, with its shaft, some 150 tons, and no overlapping, and a drum little more than half that diameter, weighing much less, but with overlapping. Mr. Bramwell's opinion was that there was less rope wear when there was overlapping with a lateral angle of 1 deg. than with no-overlapping and a lateral angle of 2 deg.

With regard to the same installation, G. W. Westgarth stated that with the flattened-strand rope 3 in. in diameter, the difference between the load at the start and at the finishing point, due to the weight of the rope alone, would be approximately 16 tons, but if a locked-coil rope 3 in. in diameter were adopted, the difference would be approximately 22 tons. He suggested that these weights were in such relationship to the useful load of 12 tons that there could be gained by their adoption, so far as the lateral angle is concerned, not only a negligible advantage, but a serious disadvantage, and the inference was that in laying out winding engines, it was most desirable that the lateral angle should be arranged for the adoption of such a rope that its weight would be in more economic relationship to its useful load.

An important point in connection with the same installation was that of selecting a proper factor of safety. Having regard to the low cage speed of about 30 ft. per second, and after taking into consideration the smooth running and direct control obtained by the use of an electric winder, it has been decided to adopt a safety factor of about 7 in lieu of the customary 9 and 10; a further reason which prompted the taking of this step is that with so large a dead load there would still be a much larger absolute margin of strength than usual, although a smaller relative margin. Thus a dead load of 20 tons and a factor of safety of 9 gave a margin of 160 tons, while with a dead load of 40 tons and a factor of safety of 7, the margin would be 240 tons (30 pp., 4 figs. *et*).

## NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

*Transactions, vol. 30, part 7, March 1915, Newcastle-upon-Tyne*

Some Tests on a Diesel Engine, W. S. Burns (abstracted)
On the Strength of Welds Made by the Oxy-Acetylene Process, Professor Campion and W. C. Gray (abstracted)
The Influence of Various Temperatures on the Properties of Admiralty Gun Metal, Professor Campion and Professor John G. Longbottom (abstracted)

### Some Tests on a Diesel Engine, W. S. Burns

The paper presents data on some tests of a Diesel engine carried out in the laboratory attached to the Department of Mechanical Engineering in the Royal Technical College, Glasgow. The present paper covers the following subjects; value of blast pressure and variation of jacket water temperature upon the running of a Diesel engine. It also describes some of the measuring apparatus used. Further data obtained from the same tests are reported in the author's paper, "Oil Fuels and Their Application to the Generation of Power," in the *Transactions of the Institute of Engineers and Shipbuilders in Scotland*, Vol. 57.

From the beginning, it was seen that the ordinary indicator diagram would not be suitable for the investigation of changes taking place in the cylinder during combustion. The combustion part of the cycle in a Diesel engine takes place when the piston is moving very slowly, so that with the usual reciprocating indicator diagram, the record of the pressure changes is crowded into a very small space. Consequently rotary indicator cards were used, and the author fully describes the method of taking such diagrams. As shown in Fig. 7A, the spring and stopper were removed from the indicator barrel, and a card consisting of a circular strip of paper, about 33 in. long by 2½ in. broad, was passed over the indicator drum and also over a wooden drum affixed to a small spindle parallel to the indicator drum. The spindle was driven from the crank shaft and was fitted with a clutch for starting and stopping the cards. To record the position of the beginning of the stroke on the cards, an electrical striker was fitted to the indicator and so adjusted as to make a mark just beneath the indicator pencil when the piston was at top dead-center. The striker was adjusted to a known point on the ordinary receiving card, the adjustment being made at the electrical contact at the flywheel as shown in Fig. B.

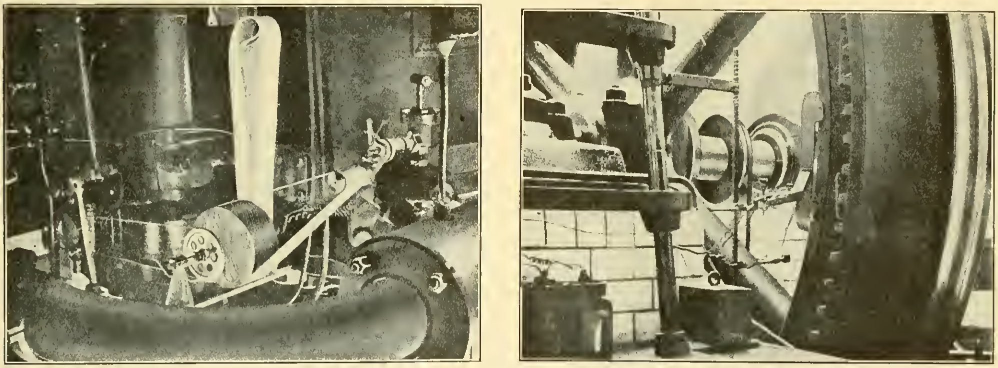


Fig. 7, A and B Arrangement for Taking Rotary Indicator Diagrams

The load was kept practically constant throughout each series of tests by adding and taking off small weights, according to whether the rope friction decreased or increased. Before starting a series of tests, the engine was run from 2 to 3 hours at the load required for that series, to insure a steady temperature condition throughout. Fig. C shows a rotary diagram taken immediately after the fuel was shut off, giving the compression and expansion of the air in the cylinder under working conditions. Equal increments of length on the atmospheric line of this diagram represent to scale equal increments of crank angles. The cards travel about 7.6 in. in one revolution, or about 25.6 in. per second, so that the paper was travelling under the indicator pencil at high speed relative to piston displacement at top and bottom dead-centers, this permitting the studying of changes of pressure in the engine cylinder at and around those points in great detail.

On one of the diagrams is shown the motion of the fuel valve to a modified scale relative to the indicator diagram. It was obtained by placing an indicator on the fuel valve in such a way that vertical displacements of the indicator pencil were proportional to the movement of the fuel valve spindle, the indicator drum being driven at a constant angular velocity by a cord from a wheel on the countershaft spindle. Elsewhere the two short vertical lines, one near the top of the compression curve and the other some distance down the expansion curve, indicate the opening and closing of the fuel valve of each diagram.

*Experiments With Different Blast Pressures:* Several series of tests were run at different blast pressures, the load remaining constant throughout each series. The usual increase of consumption with unsuitable blast air-pressure was found. For example, by dropping the blast air-pressure from 700 to 600 lb. per sq. in. at normal load (about 30 b.h.p.) the consumption is increased by about 0.37 lb. per hour. The diagram shown in Fig. M can be considered typical. The expansion line on diagram *A* shows, as at lighter loads, that the oil burns late in the stroke probably because it is not properly pulverized, thus causing increase of exhaust temperature and pressure above normal. Diagram *B* shows that combustion begins almost at the top dead center and the burning is completed considerably earlier in the stroke.

In diagrams *C* and *D* the blast pressures caused considerable irregularity about the point of ignition; sometimes combustion starts at the top dead-center, in which case a smooth expansion curve is obtained, or the pressure line followed down the dotted expansion line for some distance, when there is a sudden addition of heat, causing a peak in the expansion line. The late ignition may be due to the cooling action of the blast air. Diagram *E* shows the ignition later than *D*, with a more rapid explosion of the oil, causing a slight knock in the engine cylinder. The diagrams in Fig. N are likewise reproduced here to show how an increase in blast pressure up to the most economical pressure, increases considerably the rate of combustion of the oil. At high blast pressures, ignition is retarded and is attended by a sudden rising pressure, causing peaks on the diagrams. The ragged end of the expansion line of the diagram *C* is caused by the vibration of the indicator spring and mechanism, due to the sudden increase in pressure.

On the whole, it was found that at light loads, the excess air already in the cylinder and the inrush of blast air, with a small quantity of oil, causes late ignition and slow combustion of the fuel. Then as the load increased and the mixture of pulverized fuel and air becomes richer, there is a correspondingly earlier ignition and also an increase in the rate of propagation of the explosion. At all loads, too low a blast pressure pulverizes the oil imperfectly, causing late ignition and incomplete combustion with an increase of exhaust gases at the high temperature, which also indicates that the oil is being handled more economically. The heat given to the cooling water per unit of time at low temperature is about five times as great as the heat given at the high temperature. Tachograph records show that increase in jacket water temperature causes a slight increase of speed, principally due to the cylinder lubricating oil becoming less viscous at the high temperature.

Diagrams *A* and *B*, Fig. O, show that at moderate tem-

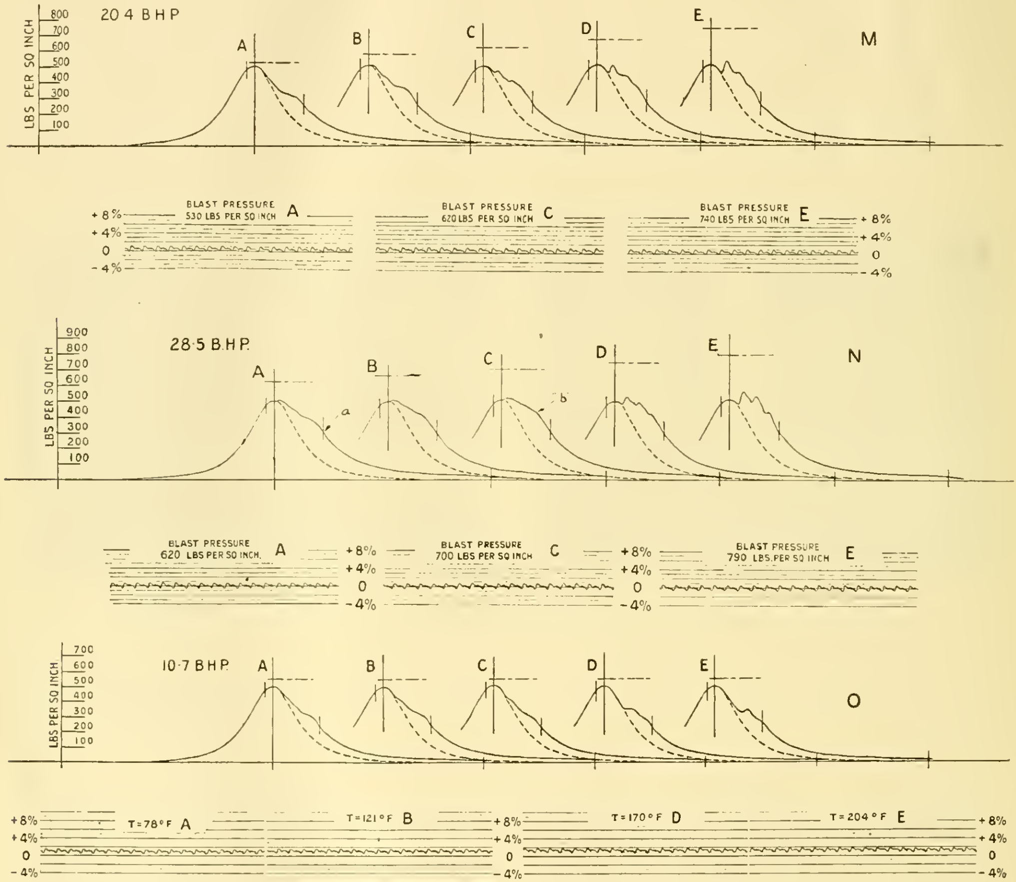



FIG. 7, C, D, E DIESEL ENGINE INDICATOR DIAGRAMS TAKEN WITH DIFFERENT BLAST AIR-PRESSURES

haust pressure and tempearture above normal, while too high a pressure causes late but violent ignition again attended by incomplete combustion of the oil.

*Variation of Water Jacket Temperature.* Fig. O illustrates the effect of the variation of cylinder water jacket temperature at low load; a similar figure in the original article shows the same at high load. It was found that the higher the temperature of the jacket water, the more economical was the engine. There is a marked decrease in the carbon dioxide and the carbon monoxide present in the exhaust gases at the high temperature, which also indicates

peratures combustion takes place late in the stroke and the rate of combustion is slow, while diagrams *D* and *E* show that as the temperature of the cylinder walls and piston increases, ignition still occurs late in the stroke, but that the rate of combustion is more rapid. As a general conclusion, the author states that at all loads, increase in water jacket temperature does not seem to affect the point of ignition of the oil, but probably causes more rapid and more complete combustion with increased efficiency.

In the discussion which followed, Professor A. L. Mel-

lanby called attention to the effect of varying the blast pressure and to the sensitiveness of the engine in responding to these changes of pressure. In Fig. N the diagrams show what takes place when the engine is working under fairly high loads. Examination of the card *A*, taken when the blast pressure was low, shows that ignition takes place earlier and that the oil burns quietly and comparatively slowly. Card *E*, taken when the blast pressure was high, shows that ignition was late, due probably to local cooling effect and that a comparatively violent explosion took place. James Richardson pointed out that Mr. Burns' work showed that at the lowest powers the conditions of fuel injection were generally a compromise between a quantity of compressed air required to pulverize satisfactorily the fuel and the cooling effect of the expansion of this compressed air as retarding ignition.

On the Strength of Welds Made by the Oxy-Acetylene Process, Professor Campion and W. C. Gray

The paper presents a general discussion on acetylene welding as well as data on the strength of welds by that process. The author starts from the statement made by Dr. C. H. Desch, to the effect that it must be admitted that a joint made by autogenous welding has not the same qualities as the original steel. Tensile tests are not conclusive in showing which part is injured, as the injury to the steel does not always affect the tensile breaking strength, but is revealed when the welded steel is subjected to shock or fatigue.

For the purpose of the present tests, a large number of welds of mild steel were prepared and submitted to static tension and repeated impact tests in the ordinary condition and also after various treatments. The first series of tests were made of round bars of mild steel, ⅝ inch in diameter, containing approximately 0.25 per cent carbon. No results for contraction of area at fracture have been recorded because it was found that in most cases the fracture was much too raged and uneven to allow of the final diameter being measured. In the results of tensile tests considerable differences were found, not only between the mean results for each treatment but between the individual bars of each set. This appears to indicate that there is an element of uncertainty about a weld, even when it has been made with the greatest care by an expert manipulator. Altogether, it would appear that an average weld might be expected to possess something like four-fifths of the strength of the unwelded steel and that the ductility would be about one-fifth. The maximum strength in tension appeared to vary to no great extent, but the ductility varied considerably from the average.

Hammering increased the ductility and reduced the strength slightly. Reheating after hammering produced a further increase in ductility and at the same time increased the maximum strength. Reheating to the same temperature without previous hammering produced a somewhat larger increase in ductility and a further small increase in strength. In specimens quenched in water and then reheated, the strength has risen to almost that of the unwelded material although elongation has been reduced. From all tests, it appears that under no circumstances does the ductility of the weld approach that of the unwelded portion.

A number of welded bars of the same material were tested under repeated impacts in a Stanton machine. The bars were notched in the center of the welded portion, the diameter at the bottom of the notching being four-tenths of an inch. From these tests it appears that an average weld might be expected to withstand about half as much as similar material unwelded. Hammering has been apparently the most effective treatment so far as increasing the fatigue resisting properties of the material is concerned, but it must be borne in mind that the heating during the welding is extremely local and consequently the metal in the immediate vicinity of the weld is liable to be at a comparatively low temperature and there is danger, when hammering, of vibrating or jarring the portion of the metal that is at black heat, which is productive of brittleness. If hammering is resorted to, the metal should be reheated to a full red heat (800 deg. cent.) in order to remove strains or brittleness which might have been set up during the process.

Reheating or annealing alone appears to be of little value so far as the increasing of fatigue resistance in the welded portion is concerned. This fact, of a portion of the material in close proximity to the weld becoming brittle from being heated to a black heat, explains also the fact observed in the tests; viz., that fracture occurred not in the center of the weld where the notch was, but in close proximity to the weld. Several microphotographs in the original article show the fracture of the original plate and that of the overheated portion after annealing.

A series of repeated impact tests on plates of different thicknesses have shown very clearly that the thicker the plate, the less reliable is the weld and the greater the reduction in strength. Thick material also generally shows less improvement by annealing.

The authors, as the result of a large number of tests and experiments upon autogenous welds, conclude that although there is a wide field of usefulness for oxy-acetylene and similar processes, considerable precaution must be exercised and due regard paid to all the conditions before making use of them, especially where the parts are likely to be subjected to considerable mechanical strain. In any case where failure tends to endanger life and limb, welds, if not entirely prohibited should be accepted with extreme caution.

In the discussion which followed, James T. Milton stated that there had been a great deal of pressure brought to bear upon Lloyds' to accept all kinds of repairs by autogenous welding but, up to the present, no repairs made by this process were accepted in places where if they failed it would mean serious disaster. Lloyds' Register prohibited, and continues to do so, the use of autogenous welding on shell plates, both of ships and of boilers and also on large and important forgings. Neither are crank shafts, repaired by autogenous welding, accepted.

Dr. C. H. Desch pointed out the desirability of distinguishing between the processes of true welding in which the metal was quite continuous in composition and structure throughout, and autogenous welding in which a zone of material fused at a high temperature was produced bordered by two zones of overheated metal. The present experiments confirm the speaker's view that the presence of a zone of overheated metal was very injurious to the dynamic properties, and that subsequent treatment did not restore the original resisting power. It was quite possible for the fused portion to be stronger in every way than the original metal: the weaker part was the intermediate overheated zone (20 pp., 4 figs. *eg*).

THE INFLUENCE OF VARIOUS TEMPERATURES ON THE PROPERTIES OF ADMIRALTY GUN METAL, Professors A. Campion and John G. Longbottom

Investigation of the influence of various temperatures on the properties of admiralty gun metal, annealing of such metal at various temperatures, and of variations in the structure of the metal when heated.

The actual composition of the material used in the research is shown by an analysis, in percentages,—copper, 87.96; tin, 9.77; iron, 0.13; lead, 0.18 and zinc, 1.94.

The tests have shown that from atmospheric temperature to about 200 deg. cent., the material suffers no appreciable change of structure. From 200 to 250 deg. cent., the results are somewhat irregular with a general indication of decreasing strength. From 250 deg. cent. the strength falls continuously until at 750 deg. cent. it is approximately nil, the ultimate elongation appearing at first to increase slightly with rise of temperature, reaching a maximum at about 140 deg. cent. At temperatures higher than this, the elongation rapidly diminishes until at 350 deg. cent. it is less than 1.5. At temperatures below 200 deg. cent. the modulus of elasticity is practically unaffected by change of temperature. Very careful tests were made to determine the constants in Unwin's equation, showing the percentage of elongation.

The results of the authors' tests compared very closely with those of Bach, as well as with those of Unwin, the latter being of particular interest because Unwin's bars were cast at different times and his tests were quite few in number. On the other hand, a marked disagreement occurred between the results of the authors, Unwin and Bach on one side and those of Dewrance on the other.

As regards the influence of annealing at different temperatures, the authors found that annealing at 250 deg. cent. produces quite as satisfactory results as annealing at 700 deg. cent., which latter has sometimes been recommended. On the other hand, however, at 700 deg. cent. the material is devoid of both strength and ductility and extreme care is necessary in the handling of the castings of large size or intricate form. Moreover, the temperature of 700 deg. cent. is dangerously near the temperature at which burning of the material would take place and a small sudden rise of temperature might severely injure, if not completely destroy the casting. Further, at a temperature of 250 deg. cent., the effects of oxidation are comparatively small. It would appear therefore that annealing at 250 deg. cent., apart from cost, offers great practical advantages as compared with that done at the higher temperature.

A careful examination of the structures of the material at various temperatures was made. A study of the equilibrium diagram of the copper-tin series of alloys indicates that little or no change should be produced by heating the material to temperatures below 450 deg. cent., followed by a moderately rapid cooling, except a growth of crystals and possibly some diffusion and redistribution of $\delta$ constituents. The specimens heated to temperatures below 200 deg. cent. showed that such was the case, but at 250 deg. cent. a somewhat remarkable and unexpected change in the structure was found to have taken place, the $\delta$ compound having apparently been almost completely absorbed by the primary and secondary $\alpha$ resulting in a nearly homogeneous structure typical of a solid solution. It is of interest that no provision for such a change is made in the equilibrium diagram as at present constructed from the works of Shepherd, and of Heycock and Neville, and the authors declare themselves unable to offer an explanation of this remarkable change.

It was found further that sudden changes in mechanical properties occur at temperatures at which, up to the present, no critical points have been recognized in the thermal curves of alloys containing over 80 per cent of copper. With the exception of the remarkable change at 225 deg. to 250 deg. cent., the microstructure of the material shows no changes sufficient to account for the alteration of mechanical properties at various temperatures and it must consequently be inferred that they have no relation to the phase changes in the alloy. In the original article a number of fractures are reproduced in actual colors, which shows clearly the remarkable manner in which the crystals grow with increase of temperatures. An examination of the series of micrographs showed that in all cases fracture appears to take place through the portion richer in tin, which filled the space between the primary $\alpha$.

The authors believe generally that the crystals are bound together by some form of cementing material, which, upon heating, loses its adhesive propetries and consequently when stress is applied, the crystals composing the mass are parted from each other.

The authors point out further that the temperature of 250 deg. cent. corresponds to the point on the curves where the strength and ductility falls rapidly off and also that it is just at the outside of the zone of irregularity previously referred to. Likewise, this happens to be the annealing temperature at which the maximum strength and ductility are obtained, while at 260 deg. cent., the thin continuous bands of $\alpha + \delta$ complexly reappear. The authors consider that the result of their investigations furnishes strong evidence in support of the existence of some form of cement between the crystalline boundaries upon which the strength and other properties are largely dependent. The authors believe that the "amorphous material" of Beilby is identical with the "cement" of Rosenhaim and Ewen, although no direct experimental evidence to prove it is as yet available.

The authors have noticed, however, during the course of the present investigation, certain phenomena which appear to furnish strong evidence in support of this view. It is a known fact that in these metals at some temperatures marked slips occur after the yield point is passed, but after a short time the material stiffens and carries a further load. In some cases as many as ten such slips have been observed between the yield point and the maximum stress of the material. These slips are invariably accompanied by an evolution of heat. In the opinion of the authors this is due to the amorphous cement crystallizing to such an extent that the adhesion between the crystals of the metals is reduced sufficiently to allow some of the crystals to part from their neighbors under the particular stress. Actual fracture is prevented, however, by the crystal faces rubbing one against the other with considerable pressure, thus reforming a quantity of the amorphous material, with the result that adhesion is again restored. This material is in turn recrystallized under the influence of heat and another slip takes place.

In the progress of tests in the present investigation it has been noticed on several occasions that the temperature suddenly rose several degrees, which in the earlier experiments was attributed to changes of voltage in the heating current. Very close observations during the later tests on the gun

metal resulted in the interesting discovery that, immediately after each of the slips mentioned above, an appreciable increase of temperature in the material took place. This observation appears to be new.

The author considers that the amorphous cement loses its ductility at a lower temperature than that at which it loses its strength, and consequently the ductility of the material deteriorates more rapidly than the strength with increasing temperature.

A brief bibliography is appended (36 pp., 38 figs. *e*).

## WESTERN SOCIETY OF ENGINEERS

*Journal, vol. 20, no. 4, April 1915, Chicago*

Operating Results of the Electrification of Steam Railways, George Gibbs, Edwin B. Katte, W. S. Murray and C. A. Goodnow (abstracted)

Founding of the Western Society of Engineers, Walter Katte

Wind Stresses in the Frames of Office Buildings, Albert Smith, W. M. Wilson (abstracted)

### Operating Results of the Electrification of Steam Railways, George Gibbs, Edwin B. Katte, W. S. Murray and C. A. Goodnow

The data presented by the speaker showed that as compared with steam operation, the first cost of electrification is not in its favor. For example, a modern steam locomotive costs about $25,000 and an electric locomotive of the same capacity, $40,000. The cost of power station, transmission lines, sub-stations and working conductors must be added to that, which will bring the equivalent cost up to $110,000; hence, there should be a large saving in operating cost to cover the increased fixed charges, or another good reason for incurring the additional expense. The New York Central electrified its lines into Grand Central Terminal because it has a bad four-track tunnel condition to deal with at the most congested point of traffic, but when electrification was decided upon, it resulted in very radical changes in the movement and operation of the trains. This latter fact makes direct comparison between the former steam and the present electric operation impossible and only a general comparison can be made. The average cost per locomotive mile from a large number of records has been found to be, on steam roads, about $0.26 including fuel, supplies, maintenance, repairs and enginehouse expenses. A similar figure for electric locomotives in and about New York City can be found to be about $0.21. If, however, fixed charges are added, the comparison becomes $0.30 for steam locomotives and about $0.60 per mile for electric locomotives, this, however, without taking into consideration the fact that conditions in the New York case permit an average of 85 miles per day for electric locomotives while the steam locomotives are averaging about 150 miles per day.

As a measure of the reliability of electric equipment comparison of the locomotive or car miles per detention is used. During the year 1914 the average locomotive miles per detention was 23,000 while the multiple unit cars averaged 51,000 miles per detention. The train minute delays due to electric power troubles totaled 840 minutes for the year, out of which 535 train minutes were due to aerial lines, 244 minutes delay to the third rail, 25 minutes to sub-stations and not a single minute's delay during the eight years of operation, to power stations. The electric locomotives used by the New York Central in express passenger service have a speed of 60 miles per hour when drawing a 1,200 ton train. The locomotive is equipped with an oil-fired flash type boiler having a capacity of 2,000 lb. of water per hour for heating through trains. The complete weight of the locomotive is 132 tons, all of which is carried in the drivers, thus giving a draw-bar pull of 66,000 lb. assuming 25 per cent adhesion.

### Wind Stresses in the Steel Frames of Office Buildings, Professor Albert Smith

The paper presents methods of computation of two, three and four bay buildings, the calculation being carried for the case of two bay buildings to the ninth story, and for three bay to the fourteenth. The author uses the method of least work, and asserts that no reliance should be placed, for safe distribution of stresses, upon the passing of the elastic limit by some fibers of an office building. The paper is of great interest, but because of its mathematical nature entirely unsuitable for abstracting. The author believes that the results given in the paper are not usable in the first and second stories, but that for buildings whose bays are equal these results will give very reliable indications of the stresses above the second floor.

### Wind Stresses in the Steel Frames of Office Buildings, Professor Wilson

The paper, presented jointly with the above paper by Professor Smith, begins by establishing certain assumptions upon which the analysis is based. From these, and certain fundamental equations, the author determines the stresses in the frame. He shows that it is possible to write as many equations for each story as there are columns in the story, plus one. As the only unknown quantities in these equations are the changes in slopes at the extremities of these columns, and the deflection in a story common to all columns, there are as many equations per story as there are unknowns. By solving these equations the slopes and deflections can be determined, and this permits one to determine the moments, which in their turn make it possible to determine the shears. With the shears in the girders known, the direct stress in any column can be determined by taking the column as a free body and equating the sum of the vertical forces equal to zero.

The paper gives further a detailed comparison of the "approximate method" with the slope-deflection method of computation, the "approximate method" being described in full. As regards the slope-deflection method, the author states that it contains not approximations, except those contained in the original assumptions, and it can be shown that the inaccuracies in the assumptions do not affect materially the results; therefore, the stresses in a frame as given by the slope-deflection method will be very accurate. The greatest value of the method is said to be not for purposes of actual calculation of buildings, but as a standard by means of which the accuracy of the approximate methods may be determined.

## CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

## MEETINGS

### NEW HAVEN, APRIL 21

The regular spring meeting of the New Haven Section was held in New Haven on April 21. The general subject of the meeting was The Development of Machine Tools, and six papers were presented on different aspects of the subject as follows: The Early History of Machine Tools, by Prof. Joseph W. Roe, Sheffield Scientific School, Yale University; Modern Developments in Milling Machines, by Luther D. Burlingame, Brown and Sharpe Manufacturing Company, Providence, R. I.; Milling Cutters and Cutting Tools, by A. L. DeLeeuw, Singer Manufacturing Company, Elizabethport, N. J.; Modern Development in Vertical Boring and Turning Machines, by E. P. Bullard, Jr., The Bullard Machine Tool Company, Bridgeport, Conn.; Special Forms of Presses for Working Sheet Metal, by Darragh deLancey, Waterbury, Conn., and Grinding as a Manufacturing Process, by H. W. Dunbar, Norton Grinding Company, Worcester, Mass.

The meeting was divided into two sessions, one in the afternoon and one in the evening. A portion of each session was given up to discussion of the papers presented at that session. The registration was 125, of whom 69 were from places outside of New Haven.

### CINCINNATI, APRIL 22

At a joint meeting of the Cincinnati Section and the Engineers' Club of Cincinnati, held on April 22, W. C. Devereaux spoke on Forecasting the Weather. The address was illustrated by lantern slides, and by such of the instruments of the Weather Bureau as may be easily transported, including the sunshine recorder, wet and dry bulb thermometer for indicating the humidity, and recorders for wind velocity and direction. The speaker outlined the methods used in obtaining the temperature, velocity and direction of the currents of air in various strata above the surface of the earth, and showed the development of a storm and its progress across the surface of the country by successive weather maps, and gave reasons for the storm's progress. The weather maps for the days of unprecedented rainfall in March and April, 1913, when the great floods occurred in the Miami Valley, were shown and discussed. The speaker concluded his remarks by a discussion of the methods used in predicting the weather in Cincinnati. About 75 members and guests were present.

### MINNESOTA, APRIL 22

A meeting of the Minnesota Section of the Society was held on April 22, at which D. W. Flowers, of the St. Paul Gas Light Company, gave a paper on The Manufacture of Illuminating Gas. Mr. Flowers confined his remarks to the manufacture of coal gas, carburetted water-gas and oil gas. He outlined in an elementary manner the principal features of the generation of gas by these three processes, and referred to the characteristics of the materials used in gas manufacture, such as coke, tar and ammonia liquor. He discussed the advantages of the various systems, pointing out the economic considerations which, in the vicinity of St. Paul, lead to the manufacture of all-water gas. He concluded with illustrations descriptive of oil gas apparatus, coal gas apparatus and water gas apparatus.

### BOSTON, APRIL 23

A joint meeting, under the charge of the A.I.E.E., was held on April 23, at which Frank W. Hodgdon, chief engineer for the directors of the Port of Boston, presented a very interesting paper on the Electrical Equipment used in the Commonwealth Pier Development for the Port of Boston. Mr. Hodgdon did not confine his remarks to the electrical equipment, but gave many details of dock and building construction, presented a large number of lantern slides, and treated the entire subject in a very comprehensive way, which led to considerable discussion at the close of his talk.

### BUFFALO, APRIL 27

A meeting of the Buffalo Engineering Society was held on April 27, at which Charles W. Parker presented a paper on Patents. Mr. Parker went into a thorough discussion of the patent laws of this country, with a full description of the various kinds of patents which can be obtained and a complete description of the methods which are followed by patent attorneys and by the patent office in Washington.

Another paper was presented by H. V. Alverson on Conservation, referring to the conservation of Niagara Falls Power. Mr. Alverson's paper dealt with the development of the power plant at Niagara Falls, with complete statistics of the power being generated and the power available, due to the flow of water in Niagara River. He also gave complete information regarding the distribution of the power in Buffalo and the surrounding cities, both in this country and in Canada. After the reading of the paper, a spirited discussion ensued, led by F. A. Lidbury of Niagara Falls, and a resolution was presented empowering the president to appoint a committee for the purpose of investigating the power situation and presenting a report to the society for their action in connection with a meeting of the Central Council of Business Men's Association, which is arranging a conference of manufacturers, Boards of Trade and Business Association of Western New York Municipalities to effect a permanent organization for a persistent movement to obtain low prices for Niagara Falls power at as early a date as possible.

At this meeting, the following officers for the ensuing season were elected: John Younger, president; W. A. James, 1st vice-president; J. G. Melendy, 2nd vice-president; W. J. Gamble, secretary; W. M. Dollar, treasurer, and David Howard and David Bell as directors for two years.

The final meeting of the season was held on May 6. This meeting was addressed by Prof. R. C. Carpenter, of Cornell University, on Concrete and Machinery for Making Cement. Professor Carpenter presented some very interesting details on the subject, and, during the discussion which followed, he gave additional interesting information. This meeting closed the season of the Buffalo Engineering Society, which now has a membership of about 325. During the season, fourteen meetings were held and the average attendance was about 150 to 175.

### NEW YORK, MAY 11

A meeting of unusual interest was held on May 11 by the New York local section on the newly developed process of metal spraying. The paper of the evening, entitled Metal Spray Processes in Engineering and Art, was presented by John Calder, member of the society, who traced the de-

velopment of the school process from the early beginning in Europe down to the improved American processes, and discussed not only the interesting theoretical considerations involved, but also the features of practical interest in the use of the process. He showed the details of the spraying instrument by slides, and pointed out the limitations of the process in certain directions. Interesting data was also given relative to the cost of spraying the various metals, and as to the costs of the blau-gas, oxygen and compressed air used. The lecture was followed by a practical demonstration of the process in the basement of the Engineering Societies Building, at which a commercial spraying instrument was shown in operation, coating various objects of metal, wood, stone, cloth and paper with brass, copper, zinc and aluminum. A more complete account of the meeting will appear in an early issue of The Journal.

## NECROLOGY

### JAMES McBRIDE

James McBride, a member of the Society since 1886, was born on April 27, 1836. When he was a very young man, he learned the trade of pattern maker. From 1858 to 1865, he was employed by the Dusquesne Engine Works at Pittsburgh at pattern making and the erection of machinery on steam boats. During this period he assisted in the erection of the machinery on thirty-seven boats. It was at this time that he obtained a Government license for engineer of the 2nd Class on the western rivers.

In the four years that followed, he established a pattern shop of his own in Pittsburgh in which he made patterns, mechanical drawings and designed machinery. He gave this up, however, to take a position as draftsman for the Root Steam Engine Company of New York, but later returned to the Dusquesne Engine Works as draftsman and designer. In 1876, he entered the employ of the New York Dye Wood Extract and Chemical Company of Brooklyn as chief engineer. Three years later, he became superintendent of the Stamford Manufacturing Company in Stamford, Conn. Mr. McBride died at his home in Stamford, Conn., on April 13.

### WILBER H. TRAVER

Wilber H. Traver was born at Mattawan, Michigan, on May 3, 1863. He had a common school education, but as the mechanical profession and especially railroad work appealed to him very strongly, he served an apprenticeship with the Michigan Central Railroad as a machinist from 1880 to 1883. In 1889, he became master mechanic for the Atchison, Topeka and Santa Fe Railroad and, following this, he held the same position with the Kansas City, Pittsburg and Gulf Railroad. In 1895, he took a position with the Rand Drill Company in the sales department and later became manager of the Chicago office of this company.

In 1906, Mr. Traver took a position with the Pneumatic Tool Company as manager of the mining department, where he remained until his death, which occurred at Houghton, Michigan, on April 15.

### JOHN M. SHERRERD

John M. Sherrerd was born at Scranton, Pa., on February 26, 1859. He graduated from Lafayette College in 1878 with high honors and, during the two following years, he took a course at the Columbia School of Mines.

After the completion of this course at Columbia, Mr. Sherrerd became chemist for Mr. Ario Pardee at Secaucus, N. J., for two years and then became connected with the Troy Steel and Iron Company where he remained thirteen years until the company went into the hands of a receiver. He was engaged in a number of capacities with this latter company, first as chief chemist, then metallurgist, and later ran the blast furnace.

In 1895, Mr. Sherrerd became connected with the Taylor Iron and Steel Company as General Sales Agent. At the time of his decease, he held the position of Assistant to the President of the Kennedy Stroh Corporation of Pittsburgh, Pa.

Mr. Sherrerd was a member of the following societies: The American Society of Civil Engineers, The American Institute of Mining Engineers, The American Society of Testing Materials, the Lake Superior Mining Institute, The National Geographical Society and the Engineers Club of New York. He died at his home in Easton, Pa., on April 16.

### EDGAR H. MUMFORD

Edgar H. Mumford was born at Groton, Mass., on Sept. 20, 1862. He was graduated from Massachusetts Institute of Technology in 1886 in the Department of Mechanical Engineering.

In 1886, he entered the service of the Union Pacific Railroad at Omaha, Nebraska, in the motive power department and left there after promotion to the position of master mechanic of the Leavenworth Division, to become superintendent of Russell Wheel & Foundry Company, Detroit, in 1889. After three years in this position, he came east and became associated with Henry R. Worthington, Inc., Brooklyn, N. Y. Shortly afterward he was placed in charge of the new foundry built by this company at Elizabeth, N. J. Mr. Mumford left this position to become manager of the New York office of Bement, Miles & Company of Philadelphia, which he opened for them at that time. He remained in this position until the summer of 1895, when he started in business for himself. With Harris Tabor and Angus Sinclair, he purchased the business of the Tabor Manufacturing Company from Manning, Maxwell and Moore and remained with it as secretary and treasurer for ten years. In 1900, the Company's plant was moved to Philadelphia, and in 1905 he resigned from it to form the E. H. Mumford Company, builders of molding machines, of which he was president and treasurer. In 1909, he became vice-president and general manager of the Mumford Molding Machine Company, where he remained until shortly before his death, at which time he was arranging to enter the molding machine business under his own name.

Mr. Mumford was for twenty years an inventor and builder of molding machines known as "Mumford Machines," and was a recognized authority on them and an expert in their application to the foundry.

He was a member of the Engineers Club, the Machinery Club, Technology Club, and the Art Club of Philadelphia. He died at his home in Plainfield, N. J., on April 18.

### GEORGE T. REISS

George T. Reiss was born in Cincinnati, Ohio, on December 6, 1849. He was educated in the common schools, supplemented by private instruction in drawing, designing and mechanical philosophy. In 1877, he became draftsman at

the old Cope and Maxwell shops in Cincinnati, but in 1878 he was placed in charge as a master machinist of the engineering department of the Niles Tool Works, which was moved from Cincinnati to Hamilton, Ohio, in 1871. He was chief mechanical engineer of the concern, later becoming superintendent of the drafting department and subsequently elected to the board of directors, of which he was also secretary. Later he became vice-president of the directorate, which position he held until the time of his death. Mr. Reiss died at his home in Hamilton on May 5.

### FRED STARK PEARSON

Fred Stark Pearson, who lost his life on May 7 in the Lusitania disaster, was born July 3, 1861, in Lowell, Mass. He graduated from Tufts College in 1885 with the degree E.E. and received the degree of M.E. in 1886.

In the early part of his career, after leaving college, he held the positions of chemist for the Boston Butter Company, superintendent of the Blue Ridge Gold Mining Company in Virginia, mining expert surveying copper mines in Texas and gold deposits in Brazil, manager of the Somerville Electric Light Company, consulting engineer for the Woburn Electric Light Company, and for Chandler Electric Light Company in Halifax, consulting engineer for the American Aluminum Company and chief engineer in the steam and electric departments of the West End Street Railway Company in Boston.

His later enterprises, the result of his organization, may be classed as electric light and power companies, electric tramway companies, telephone companies, gas companies, steam railroads, irrigation and land companies, lumber manufacturing companies and mining and chemical companies. These companies were centered principally around the following cities: Mexico City, Mexico; Rio de Janeiro and Sao Paulo, Brazil; Barcelona, Spain; Toronto, Winnipeg and Niagara Falls, Canada; and El Paso and Juarez in Texas and Northwestern Mexico.

In steam railroads, the principal ones in which he was interested are the Mexico and Northwestern Railroad from Chihuahua to El Paso in the center of several million acres of timber and mining land which his companies own, and the Denver & Salt Lake Railroad, or Moffatt System, extending now from Denver to Steamboat Springs, but to be pushed through to Salt Lake City in the near future. The details of his numerous projects, however, were handled by his New York staff, a corporation called the Pearson Engineering Corporation, Ltd., in conjunction with the local staffs in each of the cities where his public utilities were located.

Dr. Pearson was a member of a large number of technical societies, among which were the following: American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Society of Naval Engineers, the Institute of Electrical Engineers (England); the American Institute of Mining Engineers, the American Electro Chemical Society, the New York Railroad Club and the American Forestry Association.

### JOHN BIRKINBINE

John Birkinbine, whose death occurred in Cynwyd, Pa., on May 14, was born in Reading, Pa., on Nov. 16, 1844. His education was received at public schools and the Friends High School in Philadelphia, the Hill School at Pottstown, Pa., and the Polytechnic College of Pennsylvania. His studies were interrupted by military service in 1863-4 on scout duty with the Union Army under two enlistments. Later, two years were devoted to practical work in a machine shop and subsequently he was associated with the late P. L. Weimer as the firm of Weimer and Birkinbine, which operated the Weimer Machine Works at Lebanon, Pa.

Much of his work has been in mining, metallurgy and blast furnace construction. As manager for the South Mountain Mining & Iron Company, he carried on experiments with various fuels for iron ore smelting while maintaining the furnace in constant operation. The carefully recorded results obtained were widely published and are referred to in text books by other metallurgists as being the most complete made.

From his Philadelphia office, he has been sent to nearly every state and to Canada and Mexico for examinations, reports, constructions of or improvements to iron ore mines, blast furnaces, iron works, water supplies, hydraulic developments, irrigation projects, etc., and his engineering knowledge has been requisitioned by several European corporations. A number of business trips were made to Mexico beginning with a visit to the Cerro de Mercado at Durango, Mexico, before railroads were established in that part of Mexico.

Mr. Birkinbine was probably the pioneer to suggest an iron industry at the head of the Great Lakes using coke made from Pennsylvania coal and his report was an important factor in establishing the iron industry at the head of Lake Superior; the blast furnace at West Duluth, Minn., was built under his supervision. He was engaged by the State of Texas to investigate the practicability of iron manufacture in the Lone Star State. As an engineer, he coöperated with Mr. E. S. Cook of Pottstown, Pa., who did much to advance the iron industry. He was for some years consulting engineer for the Philadelphia and Reading Coal and Iron Company, and held a similar position with Mr. Thomas A. Edison during the latter's early experiments on magnetic concentration of iron ore, and with Witherbee, Sherman and Company in beneficiation tests; also for the Colorado Fuel and Iron Company for the enlargement and improvement of their works and the construction of an augmented water supply system.

He has also acted as an expert for financial interests and for a number of the greatest corporations and several large railroads in this country. He was chief engineer, vice-president and chairman of the Committee of Awards of the National Export Exposition, served on Juries of Awards at the Centennial, World's Columbian, Pan American and Cotton States General Expositions, and was named for similar duties for others.

Since its inception in 1905, he has been chairman of the Water Supply Commission of Pennsylvania, and was active in forming the Pennsylvania Forestry Association. He was also active in the formation of and served as secretary to the United States Association of Charcoal Iron Workers and for nine years edited their journal. For many years, he was special agent for the United States Geological Survey, preparing the reports on iron ores for the 11th and 12th censuses and that on manganese ores for the 12th census. He was appointed by the Secretary of the Interior as expert metallurgical engineer for the Bureau of Mines.

During his career, Mr. Birkinbine has also maintained his

specialty in hydraulic engineering, acting as engineer on water supplies for various municipalities. He has not only witnessed, but has had active participation in the development of water power for electrical energy. While he was at college, electricity was a laboratory experiment only, and the use of water power was then confined to limited volumes at low heads for direct mechanical purposes; his activities have covered the development of hydro-electric science to its present advanced stage. In 1888, he prepared a comprehensive report on the development of the great water power of the St. Louis River in Minnesota, considering a fifteen mile transmission, though no water wheel manufacturers would guarantee turbines for heads above 35 feet.

For ten years, he served as president of the Franklin Institute in Philadelphia. He was also a member of the Engineers Club of New York, The American Society for Testing Materials, the Engineers Club of Philadelphia, of which he was president in 1893, the Manufacturers Club of Philadelphia, the Pennsylvania Foundrymen's Association, the George C. Meade Post 1, G. A. R. of Philadelphia, an honorary member of the Canadian Mining Institute and a member of the Institute of Mining Engineers, of which he has been manager, vice-president and president.

## PERSONALS

Carl Stenbol has accepted a position with the Anaconda Copper Mining Company, Anaconda, Mont., as mechanical engineer and designer.

Willis W. Jourdin, until recently chief engineer of the power division of the Chino Copper Company, Hurley, New Mexico, has been placed in charge of the power plant jointly owned by the Inspiration Consolidated Copper Company and The International Smelting Company at Miami, Arizona.

M. R. Hull who, for the past six years has been connected with the engineering department of the Anaconda Copper Mining Company, at Great Falls and Anaconda, Mont., has been appointed superintendent of construction at the Washoe Smelter at Anaconda.

J. Norman Bulkley, late consulting mechanical and electrical engineer to the General Mining and Finance Corporation, Ltd., London and Johannesburg, has opened a joint office with S. C. Thomson, in New York, for the practice of consulting engineering.

Horace R. Wentzell has severed his connection as superintendent of the Bourke Machine Company of Detroit, Mich., and has become affiliated in a similar capacity with the Houk Manufacturing Company of Buffalo, N. Y.

David Moffat Myers announces that he has consolidated his practice with that of John S. Griggs, Jr., an electrical engineer with offices at 110 West 40th St., New York. Mr. Myers was formerly mechanical engineer for the United States Leather Company but since 1906, he has had an office of his own at 17 Battery Place. He has specialized on the efficient operation and design of industrial plants with special reference to steam and fuel economy and to the use of exhaust steam in the production of high over-all efficiency.

Thomas A. Edison received the Civic Forum Medal of Honor for Distinguished Public Service on May 6, 1915. President Butler of Columbia University presided. The speakers of the evening were Com. G. Marconi, Charles P. Steinmetz, Richard C. Maclaurin, Charles A. Coffin and Percy Mackaye.

The following members of the Society were speakers at the annual banquet of the students of Sibley College of Engineering of Cornell University held on April 23: Calvin W. Rice, Secretary of the Society, Thomas E. Durban of the Erie City Iron Works and Prof. D. S. Kimball of Cornell University.

On May 20, Mr. Harrington Emerson, one of the foremost efficiency engineers in the United States, addressed the Milwaukee Efficiency Society on The Natural Law of Organization.

## STUDENT BRANCHES

*Members of student branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate delivery of The Journal.*

### BROOKLYN POLYTECHNIC INSTITUTE

A regular meeting of the Brooklyn Polytechnic Institute Student Branch was held on April 17. Reports of the inspection trip, lasting ten days, which was held during the spring vacation, were given by W. A. Betts and H. A. Brandt. The trip included the cities of Cleveland, Detroit, Chicago, Cincinnati, Pittsburgh and Washington. The manufacturing plants visited were the Brown Hoisting Machinery Company and the new Pennsylvania ore docks in Cleveland, the Ford and Packard automobile plants in Detroit, the plants of the Illinois Steel Company, the By-Products Coke Company and the Pullman Palace Car Company in Chicago, the factory of the Proctor and Gamble Company in Cincinnati and the plants of the Westinghouse Machine Company, the Westinghouse Electric and Manufacturing Company and the American Bridge Company at Pittsburgh. The University of Cincinnati was also visited.

A meeting of this branch, which took the form of a convention, was held on May 1. The meeting of the afternoon was preceded by an inspection trip to Peter Doelger's Brewery in New York. At the afternoon session, Prof. W. D. Ennis spoke on The Progress of the Polytechnic Institute Student Section. He spoke of the practice which the members received in self-government by the participation in and conduction of the technical meetings. The scope and increased number of inspection trips and the large membership of the section were also mentioned. Herman Brandt, '16, gave an illustrated talk on The Una-Flow Engine, showing the history and development of this type of prime mover to date, and Prof. H. P. Hammond presented a paper on The Selection of Hydraulic Turbines, dwelling on the modern types of machines. He also gave a brief history of water wheels, and gave a short sketch of the men who were prominent in developing this type of prime mover.

In the evening, the annual dinner of the section was held in New York. The speakers were President F. W. Atkinson, Consulting Prof. George A. Orrok, Dr. M. C. Ihlseng and Dr. J. B. Chittenden.

At this meeting, the following officers were elected: Herman Brandt, chairman; George L. Kay, vice-chairman; Charles E. Rohmann, secretary; Joseph L. Kopf, treasurer.

### COLORADO AGRICULTURAL COLLEGE

At a meeting of the Colorado Agricultural College on March 10, D. R. Stephens gave an interesting talk on the tempering of high speed steels. The talk included details of the change in the structure and hardness, as well as temperature necessary. Methods of annealing tool steels were also touched upon.

S. L. Conrey gave a talk on the eight-cylinder Cadillac. After giving a short history of the development of eight-cylinder gas engines, he went into the details and advantages of the Cadillac automobile as equipped with the eight-cylinder power unit.

At a meeting of the branch on March 24, T. H. Sackett gave a talk on The Works of the Colorado Fuel and Iron Company in Pueblo. In the plant, the entire process of reducing the crude ore to iron and its subsequent transformation into rails, bolts, rods, nails, wire and other iron and steel products may be followed. Every effort is made there

to utilize all the gas from the blast furnaces, which is also used to produce steam for the power used on the grounds. Practically all the power used by the steel mills is generated in this way. This company has also a very complete machine shop and foundry, and makes a great portion of the machinery used by the mining industries of the state.

At the meeting held on April 30, Mr. Searles gave an interesting treatise on Mechanical Stokers. He followed the development of the mechanical stoker from the crude, early attempts of the inventor to the more or less successful types in use today. He concluded by mentioning the various means used to bank the fires when automatic stokers are used. E. Murray gave a very detailed description of the plant of the Denver Rock Drill Company, and emphasized the fact that this is one of the most progressive manufacturing plants in the west. It is equipped with very complete laboratories for testing the steel put into their sole product, the rock drill. As they produce but the one article they have been able to equip themselves in a very thorough manner. The shops are well managed and the workmen well protected. The machine shop is fitted with the most modern lathes, grinding machines, drill presses, etc. Besides making the ordinary post and jack-drills they are now putting out an electric drill.

#### CORNELL UNIVERSITY

A meeting of the Cornell University Student Branch was held on April 21. I. N. Knapp gave an illustrated talk on The Origin, Occurrence and Production of Petroleum and Natural Gas. He gave a general survey of the whole field of gas and oil production, touching on such phases of the subject as the different sorts of oil "sands," theories of the occurrence and origin of oil and gas methods of well-drilling and the control and extinguishing of oil and gas fires.

#### KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College on April 14, P. J. Freeman, a member of the engineering faculty and formerly mechanical engineer with the Gullett Gin Company of Arnite, Louisiana, addressed the student branch on The Mechanical Engineer in the Cotton Industry. The speaker discussed how this problem has been solved during the past century and outlined other problems which await the genius of the engineer. The speaker illustrated the problem which confronted the early growers by passing a sample of seed cotton among the members of the society and requesting them to separate the seed from the cotton fibre. The manufacture and operation of gin linter sand compresses were discussed and illustrated by means of sketches and lithographs.

C. A. Carter, a student member, gave a paper on Irrigation in Western Kansas. Mr. Carter gave a very interesting discussion on the problems of the irrigation in the western part of the state, particularly in the Arkansas Valley.

#### LEHIGH UNIVERSITY

At a meeting of the Lehigh University Branch on April 9, L. Mardaga spoke on Diesel Oil Engines and R. C. H. Heck on Speed-Reducing Gear Chains.

On May 13, the following officers were elected: C. H. Shuttler, president; W. C. Hartman, secretary; C. H. Thomas, treasurer, and G. B. Adams, librarian.

Professor Butterfield spoke on Municipal Engineering.

#### LELAND STANFORD UNIVERSITY

At the regular meeting of the Leland Stanford University held on April 27, the following officers were elected for the first semester, 1915-1916: W. H. Warren, chairman; H. F. Elliot, vice-chairman, and F. G. Hampton, secretary-treasurer. Dr. Durand was recommended to the President of The Am.Soc.M.E. for the office of honorary chairman.

Mr. Stebbins of the Engineering Faculty gave an interesting talk on his experience in Locomotive Testing.

#### MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The annual banquet of the Massachusetts Institute of Technology Student Branch was held on April 29. The attendance at the dinner was the largest in the history of the Society, 102 being present as against 65 the year before. At this meeting the following officers were elected for the ensuing year: K. C. Richmond, chairman; P. Y. Loo, vice-chairman; C. E. Shedd, secretary; J. W. Stafford, treasurer, and G. W. Tuttle, R. M. Snyder and E. W. Rounds to comprise the governing board.

The speakers of the evening were Howard Elliott, president of the New York, New Haven and Hartford Railroad; Albert B. Tenney of the C. H. Tenney Electric Company, Prof. H. W. Hayward and Prof. E. F. Miller.

#### PENNSYLVANIA STATE COLLEGE

A joint meeting of the engineering societies at the initiative of the A.S.M.E. Section of the Pennsylvania Student Branch was held on April 16. The purpose was to insure a closer relationship among the engineering students. President Garman of the mechanical engineering section presided at the meeting. Prof. E. D. Walker, dean of the engineering school, and Prof. J. A. Moyer of the A.S.M.E., spoke on Engineering and the Fellowship of Pennsylvania State College Engineers.

At a meeting of the Branch on April 30, C. F. Kennedy spoke On Mines and Mine Problems. He spoke of the general features of the mine and described in detail the colleries, breakers, hoisting engines, boiler plants and various electrical apparatus. The problems of efficiency and repairing were then discussed and intensified by the speaker's practical experience.

#### PURDUE UNIVERSITY

A meeting of Purdue University Student Branch was held on April 27. Jack Abbott, superintendent of the Lafayette City Street Railways of the Fort Wayne Northern Indiana Traction Company, spoke on The History and Comparisons of the Power Units in Use in the Lafayette Plant. After giving a brief history of reciprocating engines and steam turbines, the speaker gave the history of the plant. Not many years ago, in 1906, the middle west conceived the idea of interurban roads. To accomplish this, it was necessary to combine a number of city street car systems and to build connecting lines from city to city, touching as many small towns as possible and obtaining local passenger and freight traffic. Upon combining all the local systems, it fell to the lot of the engineer to use the engines, turbines, boilers, and other auxiliary apparatus found in the several power houses and to concentrate the best in one central station. The Lafayette station under the above conditions contains a representative of all makes and kinds of apparatus. In its day it would have been pointed out as a modern and up-to-date station.

In the plant, the coal is handled directly over storage bins on an elevated track and unloaded from dump bottom cars. It is then taken from the storage bins through an underground tunnel in which there is a narrow gauge track into a small coal car and transported by steam elevator to overhead bunkers, which are connected to hoppers in front of the boilers by down spouts that feed the coal to chain grate stokers.

The boiler room consists of two 500 h.p. boilers and four 350 h.p. boilers giving in all approximately 2500 h.p. nominal rating.

The principal driving units consist of the following: one cross-compound engine direct connected to 500 kw., 3 phase, 380 volt, 25 cycle generator; one tandem compound engine direct connected to 500 kw., 3 phase, 380 volt, 25 cycle generator; one 400 kw., 3 phase, 380 volt, 1500 r.p.m. Westinghouse Impact Reaction Turbine; one 500 kw., 2 phase, 2200 volt, 60 cycle, 3600 r.p.m. Westinghouse-Parsons turbine. Three of these units are equipped with barometric condensers and the other, the cross-compound, with a surface condenser. The condenser pumps are long stroke, slow speed.

To make a comparison of these particular units, that is, a small turbine in its infancy, with Corliss engines that have for a number of years been up to their greatest efficiency would not be fair. The engines have been giving the best efficiency. Operating at full load, 26 in. vacuum 150 lb. gauge pressure, no superheat, the 500 kw. turbine used 22.6 lb. of steam per kw.-hr. and the 400 kw. turbine, 26.5 lb. On

the other hand, the cross-compound, operating under similar conditions except that steam contained 2 per cent moisture, used 14.3 lb. of steam per i.h.p. and the tandem compound 13.5 lb.

### UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch on April 9, Mr. L. C. Morrow of the Lodge and Shipley Company gave a talk on Time Setting in a Car Shop. Mr. Morrow pointed out that the conditions which prevail in a car shop differ greatly from those of other manufacturing plants. The machines are more easily operated, the work is rougher, and the employees are for the most part unskilled. Also the weather and the seasons of the year affect the car shop men. The shops are practically open, and, in the winter, the lubricating oil freezes and other elements of like nature cause delay. The main fact, however, that the weather is cold causes the men to work steadily, and perhaps harder than in summer.

In setting the time for a particular job, the operations are broken down to their elementary movements. For example, if the operation was one of a small punch press, the movements would be something like this: Take from pile to machine, place in position, press the foot pedal, remove the work and place on finished pile. The individual movements would then be timed by means of a stop watch. With this data in hand, the final time limit would depend on such variables as number of pieces, importance of operation, materials used, interruptions by foremen or others and time for lunch. Then having taken the above into consideration, it is wise to allow a sufficient margin, which, in most cases, is 20 per cent. The speaker showed that in some kinds of work considerable time must be allowed for recuperation. Mr. Morrow concluded his talk by discussing the attitude of the employee towards the time setter. He also gave some suggestions as to the best method of getting results, and related some of his experiences.

### UNIVERSITY OF COLORADO

A meeting of the University of Colorado Student Branch was held on April 22, at which Charles W. Comstock, former state engineer, spoke on The Engineer in the Business World. During the talk, he pointed out what an engineer is or should be and advocated more thorough courses in English, history, political economy and logic in addition to the technical subjects and in place of the so called practical work, a large part of which might much better be left to be obtained outside of school. The need of preparation for the strictly "business side" of an engineer was further emphasized by the statement that engineering plans are often vetoed by boards of directors not because of some error in design or estimate, but because of the poor business aspect as seen by men in the commercial world.

### UNIVERSITY OF MINNESOTA

An open meeting of the University of Minnesota Student Branch was held on April 15. A set of five films showed very completely the important and interesting features of the manufacture of Maxwell Motor Cars. They began with the reduction of the iron from the ore and passed through the manufacture and testing methods to the shipment and selling of the cars. The series was concluded with a tour through some very beautiful mountain country, during which the car was made successfully to mount some very steep grades.

### UNIVERSITY OF MISSOURI

A meeting of the University of Missouri Student Branch was held on April 22. Prof. A. L. Westcott read a paper on Boiler Practice in St. Louis. The paper was largely an account of many tests performed by the author in the service of St. Louis Water Works system, which consists of three high service stations and one low service station. The purpose of the various tests was the reduction of the coal consumption, which was about 60,000 tons per year.

The Hawley down draft hand-fired furnace is very popular there, as it is more nearly smokeless than any other hand fired furnace. The boilers at the Baden Station were equipped with steam flow meters to determine the rate of evaporation. It was found that the rate of evaporation varied very greatly. This was due to the poor use, or rather non-control of the draft by the furnace. The non use of draft control by the furnace is due largely to the fact that dampers are unhandily arranged with respect to the firing floor. Shaft gauges and $CO_2$ recorders were installed so that readings could be taken from various parts of the furnace. Besides being valuable for determining conditions of combustion, the recorders are very useful in detecting air losses in furnace settings. In some old furnaces, these air losses reach 120 per cent. The method of detecting these "air leaks" with a $CO_2$ recorder is simple. The per cent of $CO_2$ is read as gases leave the boiler and also as they leave the furnace. The change in per cent of $CO_2$ shows how much air has leaked in through the setting. The best remedy for these air leaks is a sheet metal covering over the entire setting.

Poor boiler efficiency is due to excess air more than any other one thing. Excess air is due to fires of uneven thickness and its coming through thin spots in fire; also to holes in the fuel bed which allow larger quanities of air to pass through. This may be due to lumpy coal—good boiler practice allows no large lumps to be fired; dirty fires, where there is an accumulation of clinkers and ash, as the clinkers shut off air and allow poor mixture of gases; and excessive draft. At all times the draft should be proportional to the thickness and density of fire.

### UNIVERSITY OF WISCONSIN

At a meeting of the University of Wisconsin Student Branch on March 25, the following officers were elected: J. B. Wilkinson, president; F. T. Goes, vice-president; W. D. Harvey, treasurer, and G. C. Richardson, secretary.

At a meeting on April 8, S. I. Roth gave a paper on The Buckeyemobile.

On April 22, Fred T. Goes read a very interesting illustrated paper on the Gate City Precooling Company. This plant was installed in 1910 at San Bernardino, California, for the purpose of the precooling of freight cars before their journey to the east. The capacity of the plant is 150 cars per day. The precooled air is blown in at one end of the car from the precooler by a sirocco fan, and the warmer air is drawn from the other end of the car by another sirocco fan, thence into the precooler chamber, cooled and blown into the car, continuing this path until the car is cooled to a temperature of 40 deg. fahr. The incoming temperature is 8 deg. fahr., and the air which leaves the car is at a tempearture of 29 deg. fahr. As the suction pressure and inflowing pressure are equal, the middle of the car is kept at atmospheric pressure. The advantages are many, for the prehandling of goods to and from storage is avoided, and the time schedule between producer and market is shortened.

### WASHINGTON UNIVERSITY

At a meeting of Washington University on April 21, R. H. Tait of the Tait-Nordmeyer Engineering Company gave a general talk on Refrigeration. The speaker discussed the different designs of compressors, spherical and flat cylinder heads, single and double acting. He described the troubles with packing and varying clearance caused by change in temperature in the compressor. The different systems of ice making and refrigeration were explained. Air machines, vacuum machines, semi-flooded, flooded and expansion ammonia systems, block ice, plate ice and can ice methods were dealt with.

The cost of ice plants is about $1000 per ton capacity for plants of 30-50 ton capacity. The cost increases for larger capacities and decreases somewhat for smaller. The St. Louis Refrigeration Company has the largest ammonia transmission system in the world. They make ice and sell refrigeration to various users throughout the city. In a test made recently in that company's plant by Washington University students, their output was found to be 18 lb. of ice per ton of coal used. The Anheuser-Busch Company of this city has the largest ice plant in the world for making block ice.

## EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

### POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer.*

*In sending applications stamps should be enclosed for forwarding.*

0104 Young engineer for efficiency department of Indiana concern. Preferably young technical graduate, alert, teachable, practical, with good clear thinking head.

0106 Superintendent for plant employing about 150, in the manufacture of motors, transformers and auxiliary apparatus. Location, Canada.

0108 Head superintendent for large European concern, engaged in the manufacture of rubber shoes, technical and surgical articles, covering for rollers, tubes of all kinds, balls, toys and articles to be made of hard or other rubber, etc. Applicant must be thoroughly posted in this kind of manufacture. Foreman also wanted for these branches. Apply by letter. Name confidential.

0113 Designing draftsman, experienced on marine boilers, engines and boats. Good opening for young technical graduate. State age, experience in detail and salary expected.

0114 Shop engineer, with at least five or six years' experience in heavy and light forge work, structural, steam and electrical engineering and efficiency methods of handling material throughout the shop; also manufacture of wood and steel freight and passenger cars, electric cars and general work of similar character. Must combine practical shop knowledge with technical education; capable of handling costs and piece work, estimating, etc., with other duties. Location, Canada.

0119 Engineer with experience in testing of steam and electrical apparatus and in the operation of steam power plants. Location, Delaware.

0123 Man with four or five years' experience in designing and construction of electrical cranes, to act as draftsman and designer. Location, Canada.

0124 Works manager for plant devoted entirely to the manufacture of shrapnel shells, having approximately one hundred machine tools and, in addition, a large furnace capacity. Prefer man with experience in this line, with ability to organize quickly a new force of several hundred men. Must be well versed in machining, heat treating and furnace methods. Name strictly confidential. Apply by letter.

0129 Chief draftsman for manufacturing plant in Philadelphia. State experience, references, salary, etc.

0130 Large concern in middle west making lubricators, valves, heating specialties, carburetors, etc., desires a technical graduate with three to five years' experience, competent to follow the entire products of the company through their evolution, design and manufacture. Applicant would be required to supervise and coördinate the work of the various departments. Complete experience in this line of manufacture is not necessary, but knowledge of mill construction and maintenance would be useful. Salary depends upon qualifications.

0134 Professor of mechanical engineering. Applications will be received to July first. Prefer man of Canadian birth. Salary, $2500; session seven months. Location, Canada.

0135 Young mechanical engineer wanted who has had an excellent technical training and a year or so of good practical experience; of good character and ability; or recent graduate willing to start at low salary. Apply through Society. Location, Massachusetts.

0136 Good opportunity for first class designer; a man with chiefly drawing office experience is needed, particularly on heavy machine tools and similar machinery. Location, Pennsylvania.

0139 Machine shop foreman for engineers, founders, machinists, manufacturing sheet and structural steel, elevating and conveying machinery and ice tools. The position pays fifty cents an hour for an eight or ten hour day. New York State.

0140 Engineer or designer and draftsman in the hydraulic press line. Man experienced in hydraulics capable of making designs and drawings for special presses such as veneer, binder board, hot plate presses, etc. Location, Pennsylvania.

0143 Chemist with two or three years experience in research and industrial chemistry; for position dealing particularly along line of paints, enamels, metal coatings and work of similar character. Location, New York.

### MEN AVAILABLE

*The published notices of "men available" are made up from members of the Society. Notices are not repeated except upon special request. Names and records are kept on the office list three months, and if desired must be renewed at the end of such period.*

F-123 Industrial engineer with broad experience as consulting engineer and efficiency expert in machine shops, foundries, paper mills, etc., desires position as general manager or works manager. Would be interested in position where results would lead to business opening in firm.

F-124 Member, age 35, graduate M.E., Lehigh University, 14 years engineering experience in work requiring executive ability and tact in handling men, well qualified by training and e perience to manage concern requiring broad engineering knowledge, mechanical, electrical and mining, and also ability to organize. At present engaged as general manager of coal mining company abroad. Is planning trip to Panama Fair in June or July, and can arrange interview en route from New York to San Francisco.

F-125 Junior member, mechanical graduate 1907, experienced in advertising and publication work, is open for position as publicity agent or advertising manager. Moderate salary at beginning if position is desirable otherwise.

F-126 Member, A.S.M.E. and Institution of Mechanical Engineers, with wide experience in all technical and commercial work, and in the American, European and Japanese markets, 16 years with exporters and importers of machinery, in charge of technical department in London and Tokyo, desires responsible situation in similar capacity. Familiar with English, German, French correspondence, and some Spanish.

F-127 Member, specializing in the installation of scientific management, expects to be at liberty from June first to December first, and desires engagements in this line during that time. Speaks Spanish fluently, and would accept engagements in Latin America for the investigation of the efficiency and possibilities of improvement of enterprises, or would undertake betterment work. If it should be desired that any temporary appointment become permanent, that could be arranged.

F-128 Associate-Member, graduate M.E., three years teaching and two of practical experience as assistant superintendent of small factory, has executive ability and capable of handling men, understands efficiency and cost keeping methods, will consider teaching or practical opportunity; willing to start on low salary in position of opportunity.

F-129 Junior member, graduate M.E., University of Wisconsin, five years experience in gasolene and kerosene, marine and farm engine design, including jigs, tools and special equipment. Engaged for six months at 750 kw. power plant, designing piping systems and general equipment. During last year and a half has been in charge of mechanical end of new cereal business. Will consider any good opening which may lead to executive position. Location immaterial.

F-130 Associate-Member, graduate M.E., Lehigh University, age 30, married, seven years experience designing, inspecting, erecting, selling and superintending in steam turbines, steel, pumps and waterworks specialties, desires responsible position where good character, personality, ability and application are assets.

F-131 Author of paper at Buffalo meeting desires responsible position; interview can be arranged there.

F-132 Associate-Member, age 32, with successful sales record, desires to become associated as sales engineer with manufacturer, preferably in the Middle West, or will open office as sales representative on commission if reasonable guarantees are made. Wide acquaintance with Chicago architects and engineers. At present employed.

F-133 Member, Stevens graduate, many years practical and teaching experience, desires position as professor of mechanical engineering. At present head of department in state college.

F-134 Junior, graduate M.E., Lehigh University, several years experience as draftsman, chief engineer's assistant, foreman and manager, at present located in prominent technical institution in New York, desires summer position which would afford experience in the mechanical field. Salary and location immaterial.

F-135 Mechanical and electrical engineer, 14 years varied experience with leading concerns in the design, manufacture, operation and maintenance of gas engines, oil engines and gas producers, testing and experimental work. Familiar with the construction and operation of large gas and steam electric power plants, pumping station, etc. Good organizer with executive ability and successful in handling men, desires responsible position with manufacturing concern or as chief engineer or general superintendent of large power system for the production and distribution of power.

F-136 Student member, age 23, graduate M.E., 1915, University of Minnesota, three months experience as draftsman in heating, ventilating and power design, desires position which offers opportunity for advancement.

F-137 Manufacturing superintendent familiar with the most efficient methods in machine shop, press work and assembling; good organizer and thorough systematizer, who can turn out production on schedule time, desires position. At present in automobile line.

F-138 Railway mechanical engineer, technical graduate with 16 years railroad experience as machinist, motive power draftsman and mechanical engineer, desires similar position, or one as mechanical inspector, assistant superintendent motive power or motive power assistant to general manager. Location immaterial.

F-139 Member, technical graduate, age 37, ten years wide experience in designing, engineering, production and accounting lines in manufacturing steam, gasolene and automobile engines and light and heavy machinery; also two years consulting and betterment work in factories handling similar products. Would negotiate with engineers and accountants. Location Middle West, preferably Detroit.

F-140 Mechanical engineer with broad experience in design and construction of water tube boilers and general plate work, also designing, estimating, purchasing and assistant manager, energetic and good organizer, desires responsible position with growing concern in Middle West.

F-141 Graduate M.E., four years manufacturing and designing experience, will leave present position to obtain sales training. Salary secondary.

F-142 Associate-Member, 13 years experience in operating and superintending power plants. At present holding responsible position as chief engineer of several plants, desires similar position with greater opportunity for advancement.

F-143 Mechanical engineer with 11 years experience in shop, office and field, desires to improve his conditions.

F-144 Member, age 42, graduate of Stevens Institute of Technology, 1893, with 15 years general experience, from draftsman up through executive management, followed by seven years specializing in organization and efficiency work in both manufacturing and commercial ends in a wide variety of lines, including machine shop, manufacture of chocolate, underwear, wholesale news distribution, brass goods, foundry, paper boxes, printing and publishing, desires a permanent connection with a progressive concern, location preferred, New York or vicinity. Will invest if conditions are favorable.

F-145 Junior member, age 27, Stevens graduate, class of 1911, possesses initiative and unusual mathematical ability, with four years experience in experimental, plant and executive work, desires change. Employed in Middle West, but coming to New York about July 10th.

F-146 Mechanical engineer, age 26, unmarried, graduate of middle western university, several years experience in field and office, is open for position, preferably in construction work. Location immaterial.

F-147 Mechanical engineer, age 30, married, technically educated, 12 years practical experience with large concerns as chief draftsman, and mechanic for valves, engineering specialties, tools, automobile and special machinery, mechanical write-ups, power plant design, installations and experimenting.

F-148 Associate-Member, age 31, technical education, journeyman machinist, first class draftsman, ten years experience in shop, drawing room, testing and designing tools for manufacturing of small interchangeable parts, wants to get into similar line. Ability to handle men. Location immaterial; salary secondary to opportunity.

F-149 Sales engineer, age 30, married, wide acquaintance in the southeastern states, experienced in handling steam, gas, hydraulic and electrical equipment for largest builder in America, wishes to locate permanently in his native South in capacity of district manager, or sales agent for similar or allied lines. At present employed, but desires change for personal reasons.

F-150 Member, Cornell graduate, age 38, married, nine and one half years experience in railroad shop, testing laboratory, drafting, supervision of power plant and foreman; two years construction work, design and installation of equipment in steel mills, desires position in mechanical department of railroad, manufacturing concern or firm of engineers.

F-151 Member, age 34, technical education, married, with broad experience with leading engineers in the East on design of steam power plants, heating and fire protection systems and inspection of mill and power plant construction and equipment, desires position with large manufacturing concern; at present employed as superintendent of construction on large mill and power plant.

F-152 Technical graduate, three years experience in construction work and repair, desires to get in touch with a master mechanic or chief engineer of large industrial plant or power company. Ability to handle men. At present employed.

F-153 Associate-Member, M.E. Case School of Applied Science, age 32, married, four years experience in engineering sales work, two years designing and installation of heating and ventilating equipment for industrial plants; has travelled in Cuba and South America, desires position with manufacturing or engineering concern. Will consider very reasonable salary till ability is proven. Location middle west, preferred, but will go elsewhere for real opportunity.

F-154 Student member, 1914, M.E., graduate of Lehigh University, some machine shop and foundry experience; at

present employed as instructor of mechanical drawing, desires position.

F-155 Member, technical graduate, age 32, having two capable associates and office centrally located in Philadelphia, solicits representation for reputable manufacturer who now has some trade in Philadelphia, but has at present no direct representation. The character of the product must be such that a considerable business will be possible as a result of thorough and systematic engineering salesmanship.

F-156 Member, age 33, married, Cornell graduate, 12 years experience in manufacturing, engineering and selling, desires executive position in small city involving little or no traveling. At present machinery sales manager in Chicago for large corporation. Present salary $300.

F-157 Member, graduate Massachusetts Institute of Technology, age 36, 12 years successful experience as works manager or superintendent; thoroughly practical as well as technical. Managerial experience includes foundries, pattern shops, machine shops, erecting, sheet-metal stamping, electro-plating, lacquering, lithographing, miscellaneous machinery, power plant management, plant construction and equipment. Familiar with modern factory, and has handled from 1000 to 1500 men, desires position as works manager or superintendent.

F-158 Junior member, 1914 graduate, desires a position with a company specializing in the design of manufacturing plants.

F-159 Member, 20 years valuable and complete experience in design and construction of printers and allied trades machinery, desires engineering or executive position where this experience will be of advantage. At present employed.

F-160 Junior, age 38, sales engineer, broad experience in handling high grade mechanical specialties, large acquaintance with mill supply and machinery trade, desires to represent manufacturer in East or Middle West in capacity of district sales manager.

F-161 Technical graduate, two years shop and testing and seven years experience in teaching mechanical engineering subjects, desires position in university or technical school.

F-162 Member, graduate M.E., married, experienced in the management of the power and mechanical departments of industrial plants, and the mechanical departments of railroads; also wide and varied experience in sales and purchasing. Capable of managing coal mining property or plant manufacturing machinery. Prefer representing manufacturers of railway supplies or heavy machinery.

F-163 Member, age 39, married, with broad and thorough manufacturing experience from apprentice to agency manager in a large engineering corporation manufacturing steam and producer gas engines, producers and transmission machinery; with firm for nine years in the capacity of draftsman, designer, estimator, mechanical engineer, salesman and agency manager, also experienced in efficiency engineering, correspondent and advertising, desires position.

F-164 Graduate of Stevens, age 32, chief engineer of firm of industrial engineers, now completing construction and equipment of large manufacturing plant in South, entirely capable of general supervision of such contracts, investigating and developing prospects, as well as of preparing plans and specifications and superintending construction of any type of building, with power generation and distribution, etc., seeks new engagement. Location and salary no difficulty.

F-165 Junior member, M.I.T. graduate, age 27, married, four and one half years experience, including drafting, power plant, textile machinery, office and executive work, desires permanent position with reliable concern offering chance for advancement.

F-166 Student member, technical graduate E.E. of cooperative course, University of Cincinnati, five years practical experience in large western ice-machine and electric company. Experience embraces jig and fixture design, analysis of production costs, estimating, d.c. electric design and practical machine shop work, desires employment with engineering or manufacturing company, preferably as assistant to works manager or superintendent. At present employed. Salary secondary consideration.

F-167 Technical graduate in mechanical engineering, age 26, two years experience as mechanical draftsman in the designing and planning department of the Panama Canal, thoroughly familiar with railway equipment, dredging and excavating machinery, desires outdoor position with irrigation or power development company. Location preferred Pacific Coast or Rocky Mountain states. Present salary $1500.

F-168 Member wishes to arrange for the manufacture and marketing of an improved type of shop appliance for which there is a constantly increasing demand at a good profit.

F-169 Junior member, technical graduate, married, traffic engineer of large company manufacturing motor trucks, desires similar position with one of the best makers of trucks, located either in Buffalo, Cleveland or Detroit. By coordinating the efforts of sales manager, assistant manager and traffic engineer, the effective results of dealer, branch house or traveling salesman can be materially increased and a plan for effecting the installation of motor trucks where horses are now used, or for increasing sales, can be realized.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal

# THE JOURNAL OF

# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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## ANNUAL MEETING IN DECEMBER 1915

THE Annual Meeting of the Society will be held in New York, December 7–10. Although complete plans for the meeting have not been formulated as yet, several committees have announced their intention of holding sessions, among which are a session by the sub-committee on Railroads devoted to a discussion of Trucks for Passenger Coaches, one by the Textile Committee and another by the committee on Machine Shop Practice. The committee on Industrial Buildings will present a paper on the subject of Foundations, and the committee on Air Machinery is endeavoring to arrange for a session. *It is urged that all papers for the Annual Meeting be sent to the Secretary not later than September* 1, *and that those who contemplate contributing papers notify the Secretary in advance of this date if possible.*

# THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 July 1915 Number 7


## THE SPRING MEETING

The Spring Meeting of the Society at Buffalo, N. Y., the first meeting of the Society to be held in Buffalo, was a decided success. The meeting opened on Tuesday, June 22, and closed on Friday, June 25, with headquarters at Hotel Statler. There were 223 members registered and 201 guests, a total attendance of 424, and the figures would probably have gone even higher had it not been for the unexpectedly cold weather on Wednesday. On Thursday a party of fifty came from Cleveland by boat.

The local committees had made most complete, and even elaborate, preparations for the reception of the guests. During the time of the meeting many of the committee members were in constant attendance, and nothing was left undone that could in any way contribute to the pleasure of those who were present. The chairmen of the several local committees were the following: General Committee, David Bell; Finance Committee, D. W. Sowers; Reception Committee, H. P. Parrock; Entertainment Committee, David C. Howard; Women's Committee, Mrs. William Henry Barr; Hotel Committee, W. H. Carrier; Printing and Publicity Committee, John Younger.

A great deal of interest was shown in the technical excursions to industrial plants in Buffalo, many of which opened their doors freely to the visitors. Niagara also contributed its share of interesting features, and the Reception, Entertainment and Women's Committees were at all times ready to provide some form of entertainment. In spite of these many social attractions, however, the meeting was very obviously one of serious purpose where attendance at professional sessions and consideration of committee activities were made matters of the first importance.

There were four professional sessions arranged by the Committee on Meetings, John H. Barr, Chairman. These were held in the ball room and a private dining room of the hotel, except on Wednesday morning, when all went to Niagara Falls for the day, and met for the business meeting and a professional session in the auditorium of the Shreaded Wheat Company's factory.

Four important committee meetings were held during the convention, as follows: the Research Committee, the Local Sections Committee, the Boiler Code Committee, and the Increase of Membership Committee. The Local Sections Committee was well represented by delegates from the local sections in all parts of the country, and three sessions were held. Similarly, the Boiler Code Committee and the Increase of Membership Committee held important meetings of two sessions each. Accounts of these meetings appear elsewhere in this issue.

The headquarters were opened in the hotel for registration at 2 o'clock on Tuesday. Many took early advantage of this, and the registration on the first day amounted to over 150. At 4 o'clock a meeting of the Research Committee was held, and at 6 o'clock a conference and dinner of officers and representatives of local sections, with the Local Sections Committee. This dinner proved to be of considerable importance in connection with the development of their work.

### TUESDAY EVENING'S RECEPTION

On Tuesday evening, the party gathered in the ball room of the Hotel Statler for the informal reception by the members of the Engineering Society of Buffalo and local members of The American Society of Mechanical Engineers. Chairman David Bell, of the local committee, opened the exercises by introducing Mr. Frank B. Baird of Buffalo, who warmly welcomed the engineering guests. He said in part:

Before formally welcoming our visitors, let us ask Who are these people and why welcome them? Our visitors are a clan of dreamers whose dreams come true. They study to control those wonderful forces of nature which have attracted man for ages. First viewed with awe and superstition, these forces were afterwards studied in that process of evolution which is thousands of years old and still in its infancy.

Primitive man, sensing that he could drag a larger load than he could carry, built a sled in a cold climate, rollers in a warmer climate. Then came the first mechanical engineer, the man who first used the wheel and axle. We do not know his color, his skull long is dust, but his idea lives in the principle of locomotion. Were he here today he would be greeted as a hero.

The speaker referred to Jules Verne, the Frenchman who wished to be an engineer but was forced instead to be a

lawyer, yet who dreamed of conquering the forces of nature. Some things in his stories, designed to make them attractive, should be excused; but now, fifty years after they were written, his dreams are coming true. He referred also to John Fritz, the great mechanical engineer, who, when steel shafts of greater strength were demanded conceived and built the hollow axle.

He told of Dr. Brashear's remarkable astronomical instruments. The naked eye counts eight to twelve stars within the ten-degree angle of the lens used in stellar photography but the photograph itself, less than one foot square, will divulge more than 200,000 stars. We are only on the threshold of research, the benefits of which will come to us and our children. It is hard to conceive of the vastness of the dreams of the mechanical engineer. Hundreds of broad gauge men are at work on the problems of nature and science. These are the type of people we are to welcome and Buffalo is proud to receive them.

### REMARKS BY PRESIDENT BRASHEAR

Dr. John A. Brashear responded for the Society, beginning his remarks with an observation on the general ignorance of the wonders accomplished in the engineering world, and told, to illustrate this, to the merriment of the audience, some stories of the astonishment among the negroes of the South at the time of the Atlanta expedition to observe the eclipse of 1900.

To illustrate the remarkable advances in science and engineering, Dr. Brashear said:

I have talked with the woman who sat for the first photograph ever made in America. She was 84 years old when I knew her. The photograph was taken the year before I was born, 1839. The photograph was a daguerreotype. She had to sit still in a chair for an hour with her face covered with white powder and her eyes closed. Three great mirrors on the roof of a building were throwing light on her all the time. The picture was perfect. Today the same result is achieved in a tenth of a second.

He further continued: I have an apparatus in Pittsburgh which photographs and records the actual flight of a cannon ball or a shell from the mouth of a cannon. It will record that flight for a foot or for a mile. By that means, we determine accurately the speed of the projectile and the vibrations of the gun itself, as high as 455 vibrations a second.

I had the happy privilege of working with Professor Langley. I knew all the little flying machines with which he experimented. I saw the great model with which he had planned the first successful flight. The world said it was a failure and Langley, my good friend, died of a broken heart. Don't think that these engineers, these dreamers of great dreams that come true to benefit all mankind, have happy lives! The tragedy of Langley came to me a few years ago when I was sailing 2,000 feet above the sea in California in a flying machine.

There are on my list 180 names of men who have done something to make the world go round more smoothly on its axis, he said, and their unvarying characteristic is simplicity. The great man is the simple man who can get down and find out the reason of things.

But where will the credit for these achievements go finally? I say to the mothers, the sisters and the wives of the scientists. They bear the hard struggles; they know the pains of the achievement; they inspire. For five years Mrs. Brashear and I labored together in our little shop on the hillside in Pittsburgh making the first astronomical lens in America. I was working in the daytime, ten hours a day in the rolling mill. Nights my wife and I worked together. The critical moment of success had come. We went to our shop together that night so happy. Five years of work was to be finished. There was an accident. The lens was broken, the telescope ruined.

How I worked the next day I do not know. I was heartbroken, dulled, stupefied with grief. But up in the cottage on the hill a brave woman had gone smilingly to work. When I got home that night there was a fine supper; in the shop a new disc had been set up, the machines all made ready. And, inspired and cheered, we worked and in two months more the work of five years was regained.

Following the addresses a social hour was spent, when an elaborate buffet luncheon was served by the hosts of the evening, after which there was dancing.

### WEDNESDAY AT NIAGARA FALLS

Special cars were ready at the Hotel Statler on Wednesday morning for the day's outing at Niagara Falls. One hundred and fifty joined in the trip, arriving at the Shredded Wheat Company's factory at Niagara Falls where the business session and the professional session which followed were held. Simultaneous with these was a conference of the representatives of local sections and the Local Sections Committee.

At the business session, the report was announced of the tellers on the amendment to C-45 of the Constitution. There were 1182 votes cast: 1135 for the amendment, 5 against, and 42 defective. The effect of this amendment is to add to the list of standing committees a new Committee on Standardization.

Announcement was made of proposed amendments to C-48 and C-54 of the Constitution. The first relates to a special nominating committee and specifies:

C-48 Any group forming one per cent of the persons entitled to vote may constitute itself a Special Nominating Committee, with the same powers as the Annual Nominating Committee appointed by the President.

The second proposed amendment relates to the copyrighting of reports and papers and reads as follows:

C-54 The Society shall claim the exclusive copyright to any reports of its duly appointed committees. The Council shall waive such copyright for specific reports. The Society shall copyright all papers read before the Society, printing thereon in each instance that the paper may be reprinted by anyone after the same has been read before the Society, provided that due credit be acknowledged to the Society and the author. The policy of the Society shall be to give the professional and scientific papers read before it the widest circulation possible, with the view of making the work of the Society known, encouraging engineering progress and extending the professional reputation of its members.

The Secretary presented that portion of the report of the Committee on Special Threads for Fixtures and Fittings covering rolled thread screw shells, together

with a letter from T. C. Martin, Secretary of the National Electric Light Association, which contained the approval of the Chairman of their Lamp Committee and Committee on Wiring of Existing Buildings, of the N. E. L. A. It was voted that the report be received and printed in the usual way.

The balance of the morning after the transactions of the Society's business was devoted to the discussion of professional papers.

A number of the visitors took advantage of the opportunity to inspect the Shredded Wheat Company's plant, and at one o'clock those who had been attending the meeting, and the ladies who had accompanied the party and who had spent the morning in the enjoyment of the attractions of Niagara Falls, gathered for luncheon at the International Hotel. After luncheon, the group was photographed and then the party was divided into sections for the gorge trip, and for inspecting the power plants of Niagara.

### LECTURE BY DR. F. H. NEWELL

An entertaining lecture was given on Wednesday evening by Dr. F. H. Newell, of the University of Illinois and formerly Chief of the U. S. Reclamation Service. The subject was The Engineer as a Citizen, and beautifully colored lantern slides were used of striking views of the reclamation work. An abstract of the lecture is given elsewhere.

### PROFESSIONAL SESSIONS

On Thursday morning there were two simultaneous sessions and a concluding session on Friday morning. Fourteen papers were presented in all, several of which were highly technical in character, and drew out a thoughtful and strong discussion. The sessions were well attended, particularly the one on Friday morning. On Thursday, although there were counter-attractions in the way of excursions and opportunities for automobile trips, a large audience was maintained at both of the sessions. A list of the papers follows, and abstracts will be published in later issues of The Journal:

A Study of an Axle Shaft for a Motor Truck, John Younger

A Comparison of the Properties of Nickel, Carbon and Manganese Steel Before and After Heat Treatment, Robert R. Abbott

The Use of Corrugated Furnaces for Vertical Fire-Tube Boilers, F. W. Dean

On Measuring Gas Weights, Thos. E. Butterfield

A Basis for Rational Design of Heat Transfer Apparatus, E. E. Wilson

Influence of Disk Friction on Turbine Pump Design, F. zur Nedden

The Surface Condenser, C. F. Braun

Some Mechanical Features of the Hydration of Portland Cement and the Making of Concrete as Revealed by Microscopic Study, Nathan C. Johnson

Design of Rectangular Concrete Beams, Howard Harding

Model Experiments and the Forms of Empirical Equations, Edgar Buckingham

The Effect of Relative Humidity on an Oak Tanned Leather Belt, W. W. Bird and F. W. Roys

On the Laws of Lubrication of Journal Bearings, M. D. Hersey

The Relation Between Production and Costs, H. L. Gantt

Laps and Lapping, W. A. Knight and A. A. Case

### THURSDAY EVENING'S RECEPTION

The reception and dance on Thursday evening was one of the most delightful events which it has been the pleasure of the members to attend at any of the gatherings of the Society. Through the efforts of the local committee the arrangements had been carried to a high degree of perfection. The music was by Moll's orchestra of Rochester, N. Y., which is deservedly one of the popular orchestras of the state, and which contributed much to the pleasure of everyone who joined in the dancing. Late in the evening the party proceeded to the dining room of the Hotel Statler where a collation was served and a social hour was spent.

### ENTERTAINMENT FOR GUESTS

The receptions on Tuesday and Thursday evenings have already been referred to in this account as events of much interest. Another pleasurable occasion was the opening of the Twentieth Century Club of Buffalo by its members for the entertainment of ladies and members in attendance at the convention. Tea was served there on Thursday afternoon and a large number accepted the hospitality of the club. Many of the prominent women of Buffalo were in attendance to receive the guests.

During Wednesday and Thursday, automobiles were placed at the disposal of the visitors for trips about the city or for the purpose of reaching manufacturing plants or points of interest. A special trip for the ladies was arranged on Thursday morning to view the interesting points of the city.

Still further, the local committee had thoughtfully made provision for any of the members who so desired to use the facilities of any of the clubs of Buffalo, special stamps being issued for this purpose.

### EXCURSIONS

Accounts of the many Buffalo manufacturing plants, which extended invitations to the Society to visit their works during the convention, have already been published in the last two numbers of The Journal. That the members and their friends were appreciative of these invitations is evidenced by the numerous visits which were made. Large parties went to the works of the Lackawanna Steel Company, the Snow Steam Pump Works, the Pierce-Arrow Motor Car Company, Larkin Company, and smaller groups to various other plants. A good many stayed over on Friday afternoon for the purpose of visiting plants which time had not permitted them to inspect on the previous days.

## THE ENGINEER AS A CITIZEN

ABSTRACT OF AN ADDRESS BY F. H. NEWELL, WEDNESDAY EVENING, JUNE 23

In his devotion to technical details does the engineer overlook some of his larger duties as a citizen? This is a question that we may well ask while in the midst of our professional discussions. It has already been ably brought out in the talks of last night by President Brashear and Mr. Baird, that the engineers are "dreamers whose dreams come true." They are men who study to control the forces of nature and who have brought about, especially during the last generation, most wonderful developments along mechanical lines, increasing the strength and efficiency of each worker by a hundred or a thousand fold.

While great results have thus been achieved in the handling of inert material, in the use of iron and steel, in the control of heat and electricity, yet it may well be asked whether there has been corresponding progress on the part of the engineer in the beneficial control of human forces and sentiments? It has been asserted, and quite generally accepted as true, that the typical engineer is a man who sits in his inner office, absorbed in abstruse calculations and wholly unaware of the great changes which are taking place along other lines of growth. It has been further urged that he is not doing his whole share as a man and a citizen, while performing a giant's task in his special line. While each of us must have our specialty, yet the engineers as a whole cannot afford to be so centered upon details as to lose out in broad human interests. If, as has been asserted, the engineer is not receiving such recognition from the public as will enable him to perform the largest public service, is this not due in part to his own neglect of some of these larger matters? This is a question which I wish to raise, not for discussion at this time, but rather for further personal consideration. I will ask each of you to reflect at leisure as to whether you as an individual are doing your full share to let the public know of the achievements of other engineers and of the engineering profession as a whole to aid the public.

It has well been said that the works of the engineer should speak for themselves, but many of the greatest works cannot speak for themselves; they are out of sight, hidden from view, existing as deep and difficult foundations for lofty superstructures, or as tunnels, waterworks and sewers, the essential mechanism for which is buried far from human sight. If the public who pays the bills is to appreciate fully these great achievements, the public must be told of them in language it can understand. The ordinary man cannot and does not read the technical descriptions of these great works. He is interested in them if the larger facts are presented to him in their true perspective and in a way that he can comprehend. He is satiated with startling, sensational stories, and turns with relief to simple, but definite descriptions of engineering works and of the difficulties which have been overcome. It requires, however, something of genius to state clearly and concisely the principal facts of engineering achievements without involving these in a mass of confusing details and technical language. A writer has said, "Any fool can write a book, but it takes a genius to write a paragraph." This applies with equal force to much of our technical literature. Any man of ordinary ability can write a technical paper which perhaps he and two or three other experts can understand, but it requires a man of somewhat unusual ability to state the same facts in a shorter but interesting manner. There is hardly a technical paper which has been delivered before the Society that does not have the elements of popular interest if the important points are brought out in their true relations to ordinary human affairs.

Assuming that there is some duty along this line which has not been fully performed by the engineers individually or collectively, is it possible for us to rectify these omissions either by definite action by this and other national engineering organizations, or by co-operation among the local engineering societies? My personal belief is that the engineering profession as a whole is capable of being more immediately advanced in public esteem through strong, active, local societies than through any other one agency. These local societies to be effective, however, should be inclusive in the sense that they bring into their membership all engineers of good repute in the vicinity, and associate with them all men who are interested in engineering as a whole, and who are willing to show this interest by attending the meetings or by keeping up the annual dues. The strength of such a local society lies in its ability to diffuse information not only regarding local engineering problems, but also in bringing to the attention of its members and to the citizens of the vicinity the engineering achievements elsewhere, especially those which have a bearing upon the solution of local problems. From my experience in aiding in organizing and in conducting local societies, I cannot too strongly urge the importance of the profession as a whole of the proper stimulation of such organizations. Their best relation to the national societies is yet to be worked out, but it is a problem which undoubtedly will be solved in the near future.

Taking up a little more in detail the duties which may be and should be performed by the engineers acting in co-operation or through local and national societies, attention should be directed first to the necessity of a larger and better education of the public as to the fact, which all engineers recognize, of the superior opportunity and ability of the engineer to answer many of the vexatious questions of civic interest. There has been too general ignorance of the fact, for example, that most of the problems relating to public utilities should be solved on the basis of sound engineering. It should no longer be possible for the Governor of a large state to be unaware of the qualifications of engineers for public utility commissions and with well meaning ignorance pass over the consideration of the appointment of engineers on these commissions. The fact that a Mayor of one of the largest cities of the United States refused to appoint an engineer on a public health board because in his opinion the duties appertained to those of business men and physicians, reflects unfavorably upon the engineering profession of that city in not seeing to it that the Mayor was properly informed on the fact that most of the problems of sanitation are those purely of engineering. In other words, the ignorance of public officials and of the public in general on many of these matters, may be not so much the fault of the individuals and communities as it is of neglect on the part of the engineers as a whole to let it be known that many of these problems lie within the province of the engineer for solution.

Without going further into these details, I will, as before

stated, simply raise these points as questions for individual consideration, and take up a brief description of some of the larger pieces of engineering work of importance to all citizens which have been brought nearly to completion by the Reclamation Service of the United States. You as citizens and part owners of the great area of public lands are interested in this work; you are directly or indirectly furnishing the money and should enjoy some of the beneficial results. The work as a whole illustrates some of the "dreams which have come true," and may serve to give a little broader view of the practical applications of mechanical knowledge employed in developing the latest resources of the West. In any event, I should like to introduce you to some of the breezy western optimism and breadth of views which result from life upon the almost boundless arid lands of the west. The views which I am presenting can show only a few of the works for which over $80,000,000 of public funds have been spent, and which have rendered available for cultivation nearly 2,000,000 acres of fertile land. For this expenditure many large storage dams have been built, holding flood waters and furnishing a supply to many thousand miles of canals and distributing ditches. Connected with this work has been the construction and operation of electrical power plants, mills, steam and electric railroads, commissaries, hospitals, mines, and almost innumerable mechanical devices for the control and distribution of water to furnish opportunities for homes for many thousand families of the type which will form the backbone for a permanent and progressive citizenship, independent and self-supporting—the best and most effective of our people.

## MEETING OF THE BOILER CODE COMMITTEE

An important meeting of the Boiler Code Committee was held on Wednesday and Thursday, June 23 and 24, at the headquarters of the Spring Meeting in Buffalo, at which several important actions were taken. Perhaps the most important was that relative to the use of the A.S.M.E. symbol as a boiler stamp. At a previous meeting, the question of authorization of its use in this manner had been referred to the Council, with the result that the Council referred the matter back to the Boiler Code Committee for recommendation and report as to the preferred usage. The result of careful discussion of the subject at this meeting was a resolution offered to the Council, as follows:

It is the opinion of the Committee that the official symbol or stamp is to be used to indicate that The American Society of Mechanical Engineers' rules have been complied with in the construction of the boiler. The stamp shall be affixed by the manufacturer. Certification may be governed by law or contract.

The resolution was accepted by the Council, and it will be of interest to the boiler making industry to know that the A.S.M.E. stamp as prescribed in the Code will be open to general use for this purpose.

Another important problem that had arisen in connection with the Boiler Code was that of interpretation of the rules therein. In a number of cases questions have arisen since the Code was issued relative to application of particular rules in special cases of boiler construction, and as to the exact meaning of certain of the rules in which the application proves to be obscure. As the result of many requests for interpretation in such cases, a second resolution was offered to the Council by the Boiler Code Committee, as follows:

Your Committee requests that it be empowered to make rulings where inquiries are made respecting constructions not covered by the Code, and to interpret any parts of the Code.

This resolution was also accepted by the Council, and the Committee devoted its entire second session to the consideration of these inquiries and proper replies to them. In all, ten cases were considered and interpretations formulated. It was arranged that each case ruled upon shall be given an index number, and the ruling thus made shall stand as a permanent interpretation of the particular portion of the Code involved.

Further arrangements for the interpretation work were made at this meeting in order that no obstacle be placed in the way of the application of the Code to the industry, by a provision for quarterly meetings of the Committee, or as much oftener as may be necessary, for consideration of such inquiries for rulings. The importance of this phase of the Committee's work was fully recognized, and it is hoped that by this plan the application of the Code to conditions in any community may be facilitated and its usefulness extended.

Recognition was given to the International Engineering Works, Framingham, Mass., for the copy of official tests on boiler joints which had been made at the Watertown arsenal for this Company on May 15, 1915. The receipt of this report of test data was acknowledged, and a resolution was offered that it be placed on file in the United Engineering Library in New York City.

Consideration was given to the matter of the index that has been prepared for the Boiler Code, and it has been ordered printed with slight revisions and a change of arrangement. The index will be arranged in two parts, one a complete alphabetical index of the entire work, and the other a divisional index divided into three parts, one corresponding to each of the three principal parts of the Code. It is intended that this index shall be incorporated in the next edition of the Code, which will, in all probability, be printed early in the Fall.

The matter of further work of the Boiler Code Committee was considered at this meeting, and the result was a third resolution offered to the Council as follows:

Your Committee requests that it be empowered to take up the subject of (1) economizers; (2) pressure vessels; (3) rules for operation and care of steam boilers and pressure vessels; and (4) recommendations.

This request was also granted by the Council, and the Committee thereby authorized to proceed with this work as originally intended.

## CONFERENCE OF LOCAL SECTION REPRESENTATIVES

The conference of local sections at the Spring Meeting reflected the wisdom of the Council in appointing the Committee on Local Sections last January. The personnel of this committee is: Elliott H. Whitlock, chairman, W. F. M. Goss, Louis C. Marburg, Walter Rautenstrauch, and D. Robert Yarnall; two of the committee are members of the Council, one the president of the Cleveland Engineering Society, and another past-president of the Philadelphia Engineers' Club, and they are, therefore, well-qualified to develop this important phase of the Society's activities.

There were present delegates from all parts of the country representing the following centers where sections are established.

Atlanta, Frank H. Neely
Buffalo, David Bell, C. H. Bierbaum, W. H. Carrier, and John Younger
Chicago, P. A. Poppenhusen
Milwaukee, Louis E. Strothman
Minnesota, Max Toltz
New Haven, George S. Barnum
New York, H. R. Cobleigh
Philadelphia, D. R. Yarnall
St. Louis, E. R. Fish
San Francisco, C. F. Braun
Worcester, E. Howard Reed and James A. White

The first session of the meeting, which continued through three sessions, took the form of a dinner on Tuesday evening with after-dinner speaking confined to the subject of Local Sections. The great interest which was manifested in the conference is evidenced by the fact that at the various sessions there were present, in addition to the regular delegates, Dr. John A. Brashear, President of the Society, James Hartness, Past-President, John R. Freeman, Past-President, H. G. Reist, Vice-President, Henry Hess, Vice-President, A. M. Greene, Jr., Manager, Calvin W. Rice, Secretary, and H. Wade Hibbard. In attendance also were William P. Caine, representing Birmingham, Ala., William T. Magruder, representing Columbus, Ohio, and H. H. Esselstyn representing Detroit, Mich., which centers now have the establishment of local sections under advisement, and Luther D. Burlingame representing Providence, R. I. The only sections which were not represented at the meeting were Boston, Cincinnati and Los Angeles.

The Committee on Local Sections had collected data from which the chairman had plotted curves showing the number of meetings held during the past year by the various sections, the cost per meeting, the attendance per meeting and the cost per member per meeting. These figures brought out many discrepancies and showed that the average cost of each meeting varied from $30.00 at San Francisco to $114 at New York. Other curves showed that the cost of meetings per member per year varied from 50 cents per member to over $2.50 per member.

Each representative present was given opportunity to put on record the ideas of his section and this information should prove of great assistance to the Committee on Local Sections in formulating plans which will, as nearly as possible, unify the procedure of all sections and also establish a basis for appropriating funds for carrying on their activities, which it will be endeavored to have commensurate to the requirements of the different sections and on as liberal a basis as the various activities in which the Society is engaged will permit.

Wide differences of opinion were expressed as to the relations which should exist between the Society and the sections and as to the scope of their activities. The delegates returned to their various sections with many new ideas which should prove a boon to the work, and the investigations of the committee will be continued through correspondence so that a satisfactory solution of the question will be found as promptly as possible.

## INCREASE OF MEMBERSHIP

At the Spring Meeting the Chairmen of Sub-Committees on Increase of Membership met for the purpose of exchanging ideas, and planning ways and means of securing for the Society the support of the many leading engineers in various parts of the country who have not yet become affiliated with the Society.

The Chairman of the Committee, I. E. Moultrop, found it impossible to be present, but sent a letter addressed to those in attendance of which the following is an extract:

"I have one thought to suggest to our Committee. In almost every instance where a member of the Society has not enthusiastically responded to our request for help, he has emphasized his thoughts that people are prone to weigh the tangible returns they would receive from membership in our Society against the annual expense of that membership. This is a very practical viewpoint, but frankly, is a very short sighted and selfish one. If I were so situated that I received absolutely no tangible return for my membership in the Society, I should still feel that it was my duty to continue as a member; I should feel that I ought to do something for the mechanical engineer, something for the general good of the profession that furnishes a living to the mechanical engineers of this country. In the address given by L. B. Stillwell at the third Mid-Winter Convention of the Institute of Electrical Engineers, New York, February 17, 1915, he says in one place:

'The opinion is widely prevalent throughout the ranks of the profession that the true status of the engineer is not recognized by those about him; that the work which he has done and is doing in the world entitles him to a larger place in the public view than he now occupies and to a larger share in the administrative work of the nation, state, local community, and of our great railway and industrial corporations than he now enjoys.'

"Mr. Stillwell's statements, in my opinion, are absolutely true and the responsibility for the situation is with the mechanical engineers of this country. They do not take themselves seriously enough, and they are not a unit in trying to impress the world that the mechanical engineering profession is in importance second to none. English people are very frank in stating that the present European war is a war of engineers, and if this is so, mechanical engineering must play the principal role.

"I am not only willing but glad to make my small contribution towards the general benefit of the engineering profession, and I think every other engineer ought to feel he has a similar duty. I think we should make more of an effort to impress this viewpoint on the large number of engineers who are not but should be members of our Society."

The following were present at the two sessions of the Committee: F. H. Neely of Atlanta, W. H. Carrier of Buffalo, P. A. Poppenhusen of Chicago, H. H. Esselstyn, N. G. Reinicker and A. L. Burgan of the Michigan Committee, Max Toltz of St. Paul, J. A. Kinkead of New York, E. R. Fish of St. Louis, and C. F. Braun of San Francisco.

The members of the Committee were urged to impress those members of the Society with whom they come in contact that in no instance is an invitation to join ever extended by the Society or any of its officers as such. The work of the Committee on Increase of Membership is confined to urging the membership at large to see to it that every engineer of attainment is affiliated with the Society and giving through it his moral support to promoting the best interests of his profession.

Those associated in the work of the Committee on Increase of Membership and its Sub-Committees should always act as individuals when extending to their friends and associates an invitation to apply for membership.

Emphasis should also be made of the fact that the membership has greater opportunity now than ever before to make objection to candidates who should not be admitted. The method formerly used provided every voting member with a pamphlet containing a summary of the professional qualifications of those who had applied for membership during the previous six months.

The last issue of this pamphlet contained 208 pages of data covering 619 applicants. Inquiry proved that the great expense in publishing and distributing this information was not warranted because of the small percentage of the membership who took the time and trouble to peruse it.

In its stead was adopted a more simple but just as adequate system and at but a fraction of the cost. This consists of publishing the name, occupation, and address of the applicant listed under a heading for which his age and professional qualifications appear to fit him.

This method makes it possible for every member to examine the list every month. If any member, voting or otherwise, questions the eligibility of anyone posted, he may receive upon request a complete copy of the professional record of that applicant. Any applications for which information is requested, are held up until careful investigation is made and the member raising the question has had opportunity to give complete details, and these are either disproved or the application is indefinitely deferred. This gives the member an opportunity to secure information concerning those whom he questions without the trouble of looking through a lot of details regarding applicants he does not know.

The Membership Committee, made up of an entirely separate group of members than those working on the Increase of Membership Committees, uses the utmost care and gives most careful scrutiny to the records of the applicants, the remarks made by sponsors and any information which may be sent in by other members of the Society.

That the efforts of the Committee on Increase of Membership have borne fruit is evidenced by the following table:

RECORD OF APPLICATIONS RECEIVED MONTHLY FOR THE PAST EIGHT YEARS

(Committee on Increase of Membership Appointed in January 1912)

| | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 | 1915 |
|---|---|---|---|---|---|---|---|---|
| January | 28 | 29 | 35 | 44 | 44 | 140 | 92 | 49 |
| February | 21 | 39 | 40 | 54 | 81 | 240 | 110 | 123 |
| March | 51 | 39 | 38 | 31 | 110 | 49 | 323 | 167 |
| April | 41 | 37 | 28 | 21 | 49 | 52 | 83 | 68 |
| May | 28 | 36 | 28 | 22 | 34 | 47 | 69 | 66 |
| June | 33 | 15 | 30 | 27 | 63 | 47 | 52 | 156 |
| July | 20 | 21 | 19 | 34 | 68 | 54 | 131 | .... |
| August | 21 | 22 | 15 | 33 | 156 | 98 | 61 | .... |
| September | 17 | 26 | 28 | 37 | 74 | 188 | 68 | .... |
| October | 49 | 29 | 30 | 33 | 36 | 64 | 63 | .... |
| November | 26 | 32 | 27 | 22 | 42 | 58 | 50 | .... |
| December | 35 | 29 | 34 | 49 | 53 | 84 | 53 | .... |
| Total | 370 | 354 | 352 | 407 | 810 | 1121 | 1155 | 629 |

Owing to the general condition of business the activities of the Committee on Increase of Membership were reduced to the minimum last summer, and the result is apparent in the figures from August 1914 to January 1915. It will be noted that in the first six months of 1914 a total of 729 applications were received, whereas in the corresponding period this year 629 applications have been filed.

Many of the most prominent engineers now in the Society have joined since 1911, and in almost every instance their affiliation was the result of activity on the part of some member connected with the Committee on Increase of Membership. The high standard of the membership acquired during the past four years is shown by a perusal of the Year Book and a comparison of the members shown to have entered the Society since 1911 with those who entered prior to that time.

## COUNCIL NOTES

A meeting of the Council was held in Buffalo, Thursday, June 24, 1915, at Society Headquarters, Hotel Statler.

The President announced the appointment of a committee consisting of Charles Whiting Baker and A. M. Greene, Jr., to represent this Society in conferences to be called by the American Society of Testing Materials.

Mr. Whitlock, chairman of the Committee on Sections reported that there was a great deal of interest shown in the conference of the representatives of the sections, which was then in progress. These representatives had come from all portions of the United States, including even San Francisco and Atlanta.

The Secretary reported the deaths of B. F. Isherwood, Honorary Member, John Birkinbine, G. T. Reiss, A. L. Bowman, John P. Zipf, and James T. Halsey.

Honorary Vice-Presidents which included H. R. Towne, W. M. McFarland, J. B. F. Herreshoff, Stevenson Taylor, had been appointed to represent the Society at the services to Mr. Isherwood; at the memorial services in honor of F. S. Pearson, J. W. Lieb, F. A. Halsey, H. G. Stott, F. A. Goetze were appointed as Honorary Vice-Presidents.

Election of applicants for membership was announced, on the ballots which closed May 29, and June 19th.

The resignation of C. W. Huntington was accepted.

Nominations for officers for the ensuing year were reported by the Nominating Committee, and appear elsewhere in the Journal.

The Council confirmed the appropriations of $100 approved by the Executive Committee for the work of the Committees on Student and Junior Prizes.

Approval was given to the appointment of E. A. Stillman on the Committee on Hydraulic Flanges.

Prof. Arthur M. Greene, Jr., one of the representatives of the Society on the joint Engineers' Committee with reference to the constitutional convention, reported the progress that had been made in recommending changes in the constitution, with respect to engineering matters.

The Committee on Sections in San Francisco, consisting of F. W. Gay, Chairman, F. H. Varney, Vice-Chairman, C. F. Braun, Secretary, H. L. Terwilliger, J. T. Whittlesey, likewise the Chicago Section Committee was approved, of H. M. Montgomery, Chairman, Joseph Harrington, Vice-Chairman, Robert E. Thayer, Secretary, Charles E. Wilson and H. T. Bentley.

New Orleans was chosen as the place of the Spring Meeting, 1916. The Society has never met in New Orleans, and has been in receipt of very cordial invitations for several years past, from the members there and from the Louisiana Engineering Society.

## REPORT OF THE NOMINATING COMMITTEE

The Secretary announces the receipt of a report from the Nominating Committee in which the following names are offered as candidates for the offices indicated:

*For President:*

D. S. Jacobus, New York

*For Vice-Presidents:*

Wm. B. Jackson, Chicago, Ill.
J. Sellers Bancroft, Philadelphia, Pa.
Julian Kennedy, Pittsburgh, Pa.

*For Managers:*

John H. Barr, New York
John A. Stevens, Lowell, Mass.
H. de B. Parsons, New York

*For Treasurer:*

Wm. H. Wiley

## COMMITTEE ON PROTECTION OF INDUSTRIAL WORKERS

The Committee on Meetings has recently established a Sub-committee on Protection of Industrial Workers. The members of this new committee are: John H. Barr, *Chairman;* Melville W. Mix; John Price Jackson; William A. Viall; John W. Upp.

This committee desires to avoid all unnecessary duplication of work or conflict with the activities of other organizations, but is anxious to perform its part in bringing about the standardization of effective and practical protective devices and methods.

In order to define properly its scope and determine its limits of activity it solicits information as to what has been done and is being done through other agencies. These agencies include state bureaus, insurance interests, organized societies or their committees, departments of industrial concerns and individuals. Suggestions as to sources of such information, especially reports of committees and codes for safeguarding industrial risks, are solicited. The new committee of the A.S.M.E. asks the assistance of those already engaged in the safety movement, and desires to reciprocate by coöperating with others interested in establishing a more systematic practice in the reduction of industrial accidents.

It is the intention of the committee not to hastily recommend standards; any action in that direction will only follow mature consideration of all the pertinent evidence available. An effort will be made to review the work of other agencies and to secure the advice and opinions of those who can speak with authority before attempting any specific recommendations.

The field which may be covered is a large one and the committee will probably find it desirable to restrict itself to the consideration of certain classes of risks at the beginning of its work, extending to other lines later, as conditions and development may warrant.

The first work will be a survey and digest of what has been done, having particular regard to legal codes which have been adopted in various States, regulations and requirements of insurance organizations, and codes which have been adopted by other associations.

It is obvious that such safeguards as should be applied to machinery can best be supplied with the machines by the maker. This procedure will result in guards better in design and lower in cost than if made by hand in the works of the purchaser. No doubt the purchaser would give preference, other things being at all equal, to machines provided by the maker with well designed protective features. The manufacturer will appreciate the value of such features as selling points, especially after these get some vogue.

The great obstacle to the adoption of this practice of "built in" safeguards is the diversity of requirements and conflicting regulations in force in different sections of the territory over which any given product is distributed.

If The American Society of Mechanical Engineers, coöperating with other agencies, can effect an approach to uniform requirements in this matter, it will materially contribute to the reduction of accidents, and will vastly reduce the annoyances incidental to complying with legal and insurance requirements.

To expedite an approach to this desirable estate is the first aim of the Committee on Protection of Industrial Workers.

Members of the Four Group Juries of Panama-Pacific International Exposition

## INTERNATIONAL JURY OF AWARDS

### Panama-Pacific International Exposition

On this page is published a photograph of the four group Juries of Awards of the Panama-Pacific International Exposition having to do with machinery exhibits. The names of the gentlemen seated, reading from left to right, are: Prof. H. Wade Hibbard, Mem. Am. Soc. M. E.; Prof. Charles E. Lucke, Mem. Am. Soc. M. E.; Prof. John T. Faig, Mem. Am. Soc. M. E.; J. C. Mengel; George W. Dickie, Vice-President, Am. Soc. M. E.; Lieut. G. W. Danforth, Chief of the Dept. of Machinery; W. H. Onken, Jr.; Prof. C. M. Jansky; Geo. M. Brill, Mem. and Past Vice-President, Am. Soc. M. E.; Emil Fischer and Calvin W. Rice, Secretary of the Am. Soc. M. E. Those standing are, from left to right: Captain B. C. Bryan, U. S. N.; Fred R. Low, Mem. Am. Soc. M. E.; John Hunter, Manager Am. Soc. M. E.; Captain C. A. McAllister; F. J. Frank; D. S. Watkins; W. H. Crosby; Cecil P. Poole, Mem. Am. Soc. M. E.; Carl Hering; H. W. Bringhurst; Thomas Norriss; Prof. Wm. H. Kavanaugh, Mem. Am. Soc. M. E.; Jesse M. Smith, Mem. and Past-President, Am. Soc. M. E., and N. A. Bowers.

The exhibits in the machinery buildings and those in the exposition generally which had to do with mechanical and electrical devices were divided nearly equally among four group juries. These juries were smaller than in previous expositions for the reason that it has been found that a small group is more efficient than a large one.

The chairmen of the respective groups were: Mr. Dickie, Tools for Shaping Wood and Metals; Mr. Brill, General Machinery and Accessories; Mr. Low, Steam, Gas, Hydraulic and Other Motors; and Mr. Onken, Electrical Machinery. These gentlemen, together with the Chief of Exhibits, Mr. Danforth, became members of the Grand Jury which is still in session.

There were over 600 separate exhibits, about 150 to each group jury, and, in turn, each of the exhibits contained one or more items for which the exhibitor wished separate consideration.

The work of the juries consisted in passing upon each individual item, assigning a mark on a scale of 100, to a definite schedule representing the features which one should take into account in judging the exhibit, such as its usefulness, attractiveness, instructiveness, length of time the firm making it had been in business, whether or not the firm had received previous

awards for the same lines of manufacture, etc. The sum of the individual marks which each member of the group jury secured was reported to the secretary of his group and the average taken. This indicated whether there should be given no award, honorable mention, bronze medal, silver medal, gold medal or medal of honor, and the vote was taken by the entire group confirming the award.

The care and unanimity of judgment of the individual members of the jury was indicated by the fact that the scheme of marking was so well thought out, and methods of arriving at judgments so definite, that the percentage variation from the average was usually very slight. Any person's individual judgment after the awards had been made by the group jury was in turn recommended to the superior jury for its review.

## ENDORSEMENT OF THE BOILER CODE

Full endorsement of the Boiler Code as a set of rules for stationary boiler construction was the result of a resolution adopted by the Master Boiler Makers' Association at its ninth annual convention held recently at Chicago. The Executive Committee of the Association, after investigation, made the recommendation that the Association should adopt the A. S. M. E. Boiler Code, and this recommendation was favorably voted upon by the Association. The opinion was expressed that the Boiler Code is the best set of boiler rules that has ever been published and it was hoped that it would become a standard throughout the entire country.

Also advices have just been received that the A.S.M.E. Boiler Code has been adopted by the Industrial Board of the State of Pennsylvania and by the Board of Boiler Rules of the City of Detroit as their standards of boiler construction in their respective districts. It has also been reported that the use of the A.S.M.E. Boiler Code is being strongly agitated in the State of California, as well as in a number of other States, and it is said to be more than likely that it will be the standard of boiler construction in a large proportion of the States of the Union before the end of the year.

## WORCESTER POLYTECHNIC INSTITUTE

The fiftieth anniversary of the founding of the Worcester Polytechnic Institute was celebrated on June 9. Delegates from nearly ninety colleges, universities and technical schools and from eight engineering societies were present. The Society was represented by Dr. John A. Brashear, President, and Calvin W. Rice, Secretary. Among the speakers were David I. Walsh, Governor of Massachusetts; A. Lawrence Lowell, L.L.D., president of Harvard University, and George I. Alden, of the board of trustees of the Institute and member Am. Soc. M. E.


Worcester Polytechnic Institute

Ira N. Hollis, president of the Institute, in his introductory address, expressed his regret that important duties elsewhere prevented President Wilson and Major-General Goethals from attending the function. He traced the connection between the hard experience of the men who had, on both sides, gone through the four years of the Civil War, and the subsequent rapid growth of the American industries led, to a large extent, by the men who, in the words of the speaker, have " brought away from four years of hard fighting, clean hearts." The problem of the day in this country is the necessity of greater care of our natural resources and less waste of available material. Recent laws have not accomplished as much by direct enforcement as they have by indirection, by public discussion, or by the formation of public opinion. In this aspect of American life the universities and colleges have a more important function than the legislatures.

President Lowell compared the life led by the Romans with that of the present generation. The conditions of life were profoundly different from what they are today, and in many cases the gulf in moral conceptions was nearly as deep: in Athens, Plato and Socrates said that slavery was an absolute necessity, not only for human prosperity but still more for human progress. It was not so much the change in morals, as the progress in engineering, control of the forces of nature, that brought about the establishment of the new, and better order of things, but, President Lowell added with emphasis, in controlling the forces of nature, one should know something of the com-

munity in which one lives, and the effects which a certain application of these forces will produce on the life of the community.

The same strain, the imperious need of a connection between the work of the engineer as such as a member of the community of which he is a part, was still more forcibly impressed in the address of Governor Walsh of Massachusetts. An institution like the Worcester Polytechnic Institute, he said, is specially valuable to the commonwealth in that it equips men to grapple with the problems of government, and to " preserve the blessings and the liberties the people enjoy unsullied and unstained," a significant statement when addressed to a purely technical institution.

The address of George I. Alden was given before a meeting of the local section of The American Society of Mechanical Engineers, held in the afternoon and simultaneous with the celebration exercises. His address appears elsewhere in this issue.

## CONVENTION OF THE NATIONAL ASSOCIATION OF CORPORATION SCHOOLS

Of general interest in connection with the meeting on June 8 of the Worcester local section of the Society, and of the celebration of the fiftieth anniversary of the foundation of Worcester Polytechnic Institute, referred to elsewhere in this issue, is the third annual convention of the National Association of Corporation Schools that was held at Worcester at that time. The meetings which extended over four days, June 8-11, were presided over by Charles P. Steinmetz, president of the Association, Mem. Am. Soc. M.E., and they were devoted to discussions of the many important problems entering into industrial education, such as trade apprenticeship, special apprenticeship schools, vocational guidance, office work schools, etc. More than 150 representatives of many of the largest industrial corporations in the country were present.

The address of welcome was made by George I. Alden, president of the Norton Companies, who gave the reasons why such large corporations may conduct schools in their own works and at their own expense. He pointed out the great opportunity offered by the Association for corporations to come into closer relations of personal contact, knowledge, and interest with their employees, to offer them vocational guidance, to increase the wages of employees by increasing their specific knowledge, and consequently their value to the corporation, and thus secure a unity, permanence, and efficiency throughout the whole organization, which will be of mutual benefit to all.

In connection with the meetings of the Association which were held in Higgins Hall of the Worcester Boys' Trade School, the memory of Milton P. Higgins, who was a member of the Society, was honored as founder of the school. Mr. Higgins, who was referred to as the father of trade schools, believed that the productive shop was an essential factor in successful trade training, and his early work in connection with the Polytechnic Institute and later—in founding the Trade School, which was the culmination of his twenty-eight years of business life at the Polytechnic Institute, proved that his belief was well founded. His memory was honored by the presentation of two fine bronze tablets which have been placed by his family at either side of the entrance of the Trade School for Boys building.

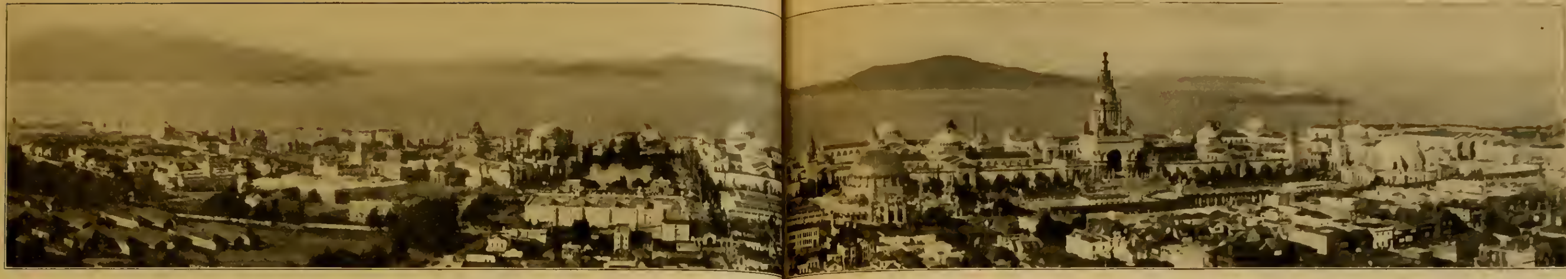
## JOHNS HOPKINS UNIVERSITY

On May 20, Dr. Frank J. Goodnow was installed as the third president of Johns Hopkins University at Baltimore, Md. The inauguration was preceded by a procession of the delegates consisting of presidents of more than fifty American and Canadian colleges and universities, faculties, trustees, alumni and graduate and medical students. The Society was represented by Prof. Carl C. Thomas, professor of mechanical engineering at the University. Dr. Goodnow in accepting the responsibilities of the office, made an address on Modern Educational Ideals. He said in part:

The complaint is often made that modern education is too practical in its aims, and as a consequence, the coming generation will lose much of the beauty and richness of life which those of the present owe to their pursuit in past years of what are usually called cultural as opposed to vocational studies. An examination of the history of universities would seem to show that almost everywhere and at almost every period the primary purpose of those seeking an education has been in very large measure a distinctly practical one. This purpose has been to acquire proficiency in the profession which they intended to follow. Even in the earliest time, tendencies were toward the practical side, and gradually subjects crept into the universities which were once considered in the nature of trades, but which were later looked upon as learned professions. The first of the new professions to be recognized by the university was medicine. Just as the development of an approximately scientific medicine resulted in transforming medicine from a trade into a learned profession, so the development of the engineering sciences has made the engineer out of the artisan, the architect out of the builder, and the scientific chemist out of the alchemist. At the present time, furthermore, new sciences and professions are in the making, such as the scientific agriculturist, the scientific forester, the naval architect, and the efficiency engineer.

It may be truthfully said, however, that educational ideals while perhaps more practical than formerly, are really to be distinguished from former ideals by reason of the fact that they are broader and more comprehensive. We no longer consider education as purely vocational or purely cultural. We no longer confine our study to theology and philosophy or to literature and mathematics. The functions of modern education are manifold.

They include the disciplinary training of the young along general lines, the transmission of that particular knowledge of the past which will do most to develop persons of culture, the applications of scientific methods to the conduct of the



Panoramic View of the Panama-Pacific International Exposition

ordinary affairs of life, the increase of our knowledge through research and investigation and the rendering of public service. None of those ideals is to be despised as unworthy of pursuit by men of learning. None perhaps may be selected as more worthy of pursuit than the rest.

On the following day, Dr. Henry C. Adams, professor of history of the University of Michigan and the first graduate of Johns Hopkins University, gave an address at the dedication of Gilman Hall. It sounded very forcibly the call to the study of those things contributing to the larger life of mankind without reference to the utilitarian objects of study, and was a plea for the things of the spirit.

Following Dr. Adams, and as the final feature of the program, General Goethals made a splendid address at the dedication of the Engineering buildings. After having pointed out the wonderful development of the creative arts in the last century, the speaker defined the relation between material progress and the moral progress of mankind. He said further:

> In man much of the brute still remains, but, although no marked progress can be observed in the subjugation or eradication of human passions, the engineer has shown advancement in his cult, the direction of the great sources of power in nature to the use and convenience of man. The present war may be expected to be followed by an era of great industrial advance. Notwithstanding its horrors, war assists progress, as new industries are developed, and inventive genius is aroused and stimulated.
>
> The work of the engineer is gradually tending to bring him into closer contact with other spheres of activity: with the physician in the preservation of public health; the lawyer in the drafting of contracts, enforcing and perhaps contesting them; perhaps even with the clergy in the handling of motley crowds in construction camps.
>
> In the United States, it was the army that supplied the first engineers. West Point was the first, and for some time the only technical school in the country, and its graduates ranked high among the engineers of the United States. Later, when technical education was undertaken by the colleges and universities, graduates of the Military Academy were found among instructors and professors. Furthermore, it was the army which started the great work which subsequently developed into what is now known as the U. S. Geological Survey and the Coast and Geodetic Survey.

The speaker proceeded then to give a brief but highly interesting account of the creation of the department of engineering at the Johns Hopkins University, and made an eloquent defense of the principles laid at the foundation of its program. After all, in the words of Maj. Gen. Goethals, it is not the amount of technical information that is of importance. What is needed is so to train the mind that it can grapple with reasonable hope of successful issue the various problems that will arise in after life; and this is accomplished best by a thorough grounding in and mastery of the theory of the fundamentals.

## THE GETTING-TOGETHER OF THE ENGINEERING PROFESSION AT SAN FRANCISCO

Traveling by the Engineers' Special to the International Engineering Congress at San Francisco will afford a unique opportunity for engineers and their friends to meet, on one train, the officers and members of the five national engineering societies under whose auspices the Congress is being held.

For a number of years, there has been developing a spirit of coöperation among the national engineering societies, and it is believed that the Congress will serve to unite further not only the engineering societies of America but also those of the entire world in one common effort.

The details of the excursion to San Francisco are briefly as follows:

Round trip ticket, via the Engineers' Special and returning by any route, can be purchased for $98.80. Pullman service and meals are of course extra.

The train leaves New York City at 7:45 p. m. on Thursday, September 9, and arrives in San Francisco at 9 o'clock on the evening of Wednesday, September 15.

The outgoing trip will allow stop-overs at Niagara Falls, Colorado Springs and the Grand Canyon.

Each of the national engineering societies will hold separate professional meetings on Thursday, September 16 and Friday, September 17. On Saturday and Sunday, September 18 and 19, excursions to points of engineering interest will be organized. These excursions include visits to the Potrero Gas Works, the largest gas station on the Pacific Coast, the San Francisco High Pressure Fire System, the Great Western Power Company's Hydroelectric Development, the Spaulding-Drum Development of the Pacific Gas and Electric Company and the Coalinga Oil Fields. During the following week, beginning September 20, the sessions of the Congress will be held jointly.

Col. G. W. Goethals will act as Honorary President of the Congress and is expected to preside in person over its general sessions. Prof. W. F. Durand is chairman and W. A. Cattell, secretary.

The papers presented will cover the general field of engineering and are intended to treat the various topics in a broad and comprehensive manner, with special reference to the important lines of progress during the past decade, the present most approved practices and the lines of present and future development. Furthermore, each will be accompanied by a bibliography of its subject.

The Congress has been handled with special wisdom on the part of a very loyal committee of which Prof. W. F. Durand is chairman, and by A. M. Hunt, chairman of the meetings committee. These men have given several years of unselfish devotion to the work, without remuneration of any kind. Notwithstanding this, the cost of literature, maintenance of headquarters, printing and publication of papers will be considerable and the Engineering Societies have undertaken to underwrite these expenses, but it is earnestly hoped that the members at large will support the Congress by their coöperation. The fee for membership in the Congress is only five dollars, but if a sufficient number of members enroll, the entire expense will be paid without calling upon the parent societies.

The Congress is a celebration by the United States of the greatest engineering achievement ever undertaken in the history of the world. It is fitting, therefore, that every engineer should be officially represented in its membership.

The following is a partial list of those who have signified their intention of attending the Congress and of journeying by the Engineers' Special. In this partial list only members of this Society are included. A total of 145 are now scheduled for the official train from New York and 21 for the train from New Orleans.

Nicholas S. Hill
Edwin B. Katte
Bradley Stoughton
Leonard Metcalf
Wm. H. Wiley and Mrs. Wiley
John H. Bernhard and Mrs. M. B. Bernhard-Nable
G. R. Tuska and Mrs. Tuska
W. L. Saunders
L. K. Comstock and party
James Hartness and Mrs. Hartness
R. J. Hill and Mrs. Hill
G. W. Fuller and Mrs. Fuller
Calvin W. Rice
Alex. C. Humphreys, Mrs. Humphreys and party
Ira H. Woolson and Mrs. Woolson
Charles A. Mead
A. Stucki, Mrs. Stucki and party
Ferdinand L. Schmidt and Mrs. Schmidt
A. H. Goldingham and Mrs. Goldingham
R. M. Clayton and party
Paul C. Philipp
Laurence C. Bowes
Reid Jones
Paul H. Grimm
W. J. A. London
H. J. Freyn and Mrs. Freyn
R. V. Norris
Robert B. Wolf and party
James M. Dodge, Mrs. Dodge and party
W. R. Warner, Mrs. Warner and party
Carl F. Dietz and Mrs. Dietz
P. M. Lincoln, Mrs. Lincoln and party
Henry G. Reist and Mrs. Reist
Robert W. Hunt
Frank B. Gilbreth and Mrs. Gilbreth

The headquarters of the Society will be at the Hotel Clift. The local arrangements will be in charge of a Committee on Local Affairs. A general program of the Congress and of the excursions will be mailed to members of the Society on request.

# APPLICATIONS FOR MEMBERSHIP

## TO BE VOTED FOR ON AUGUST 10, 1915

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of grading are also posted.

*The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned.* All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before August 10, 1915.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Adams, James F., Supt. and Vice-Pres., The Canister Co., Phillipsburg, N. J.

Alquist, Karl, Engr., General Elec. Co., Schenectady, N. Y.

Appler, A. Benjamin, Mech. Engr., The Delaware & Hudson Co., Watervliet, N. Y.

Auten, James E., Asst. Supt. Bldgs. and Equipment, Cadillac Motor Car Co., Detroit, Mich.

Bareuther, Adolph A., Insptr., The Panama Canal, Washton, D. C.

Berthold, Frank C., Mech. Foreman, Illinois Steel Co., Gary, Ind.

Bösch, Frederick W., Designing and Cons. Engr., Murray Iron Works, Burlington, Ia.

Boynton, John E., Ch. Engr., American Brick Co., Lincoln, Ill.

Brooks, Percy C., Vice-Pres., Canadian Fairbanks Morse Co., Ltd., Toronto, Ont., Can.

Brown, John W., Jr., Cons. Engr., Baltimore, Md.

Champion, David J., Pres., Champion Rivet Co., Cleveland, Ohio

Cohen, Abraham S., Mech. Engr., with C. L. Howes, M.E., Boston, Mass.

Coker, James L., Jr., Vice-Pres., Carolina Fiber Co., Hartsville, S. C.

Collister, George F., Mgr., Crucible and Alloy Steel Sales, The Betz Pierce Co., Cleveland, Ohio

Conklin, Harry R., Mining and Electrical Engr., Joplin, Mo.

Connelly, Laurence E., Vice-Pres., The D. Connelly Boiler Co., Cleveland, Ohio

Connelly, William C., Pres., The D. Connelly Boiler Co., Cleveland, Ohio

Covell, Grant A., Dean of Sch. of Engrg. and Mech. Arts, Oregon Agri. College, Corvallis, Ore.

Cunningham, Christopher, Pres., The Christopher Cunningham Co., Brooklyn, N. Y.

Dyer, Orville K., Asst. Sales Mgr., Buffalo Forge Co., Buffalo, N. Y.

Elliott, William S., Pres., Elliott Co., and Pres., Liberty Mfg. Co., Pittsburgh, Pa.

Fogarty, Michael, Boiler Mfr., Michael Fogarty Inc., New York

Fredette, John, Supt. Tools and Equipment, The Westinghouse Mch. Co., East Pittsburgh, Pa.

Fritts, Charles E., Elec. Engr., Metropolitan St. Rwy. Co., Kansas City, Mo.

Fuller, Charles E., Supt. Motive Pwr. and Mchy., Union Pacific R.R. Co., Omaha, Nebr.

Gage, Victor R., Asst. Prof. Exper. Engrg., Cornell University, Ithaca, N. Y.

Georg, Theodore, Ch. Draftsman, Alberger Pump & Condenser Co., Newburgh, N. Y.

Gorton, Charles E., Gorton & Lidgerwood Co., New York

Grace, John F., Designing Engr., Henry R. Worthington, N. J.

Gunby, Frank McC., Specl. Asst., Charles T. Main, Engr., Boston, Mass.

Hansen, Jens H., Mech. Engr., The Pelton Water Wheel Co., San Francisco, Cal.

Henderson, Ernest G., Vice-Pres. and Mgr., The Canadian Salt Co. Ltd., Windsor, Ont., Can.

Holt, Pliny E., Vice-Pres. and Genl. Mgr., The Holt Mfg. Co., Stockton, Cal.

Hopkins, Lloyd C., Engr. and Designer, The Smith Gas Pwr. Co., Lexington, Ohio

Horsman, Herbert W., Head of Planning and Rate Fixing Dept., Associated Equipment Co., Ltd., London, Eng.

Hubbell, Lyman P., Pres., Fillmore Ave. Fdy. & Iron Wks. Inc., Buffalo, N. Y.

Hunter, Samuel R., Genl. Supt., Rawleigh-Schryer Co., Freeport, Ill.

Johnson, Frank E., Supt., The Kelly & Jones Co., Greensburg, Pa.

Jones, Philip, Cons. Engr., Pinal Dome Oil & Refining Cos., Santa Maria, Cal.

Keane, Frank, Production Mgr. and Engr., Fritz Carburetor Co., Norristown, Pa.

Kettering, Charles F., Vice-Pres. and Genl. Mgr., The Dayton Engrg. Lab. Co., Dayton, Ohio

Kindlund, Martin G., Marine Architect and Cons. Engr., New York

Knapp, Edwin R., Prof. of Descrip. Geometry and Mech. Drawing, Stevens Inst. of Tech., Hoboken, N. J.

Lander, Roswell S., Assoc. Engr., The Soper Engrg. Co., Chattanooga, Tenn.

Lane, Frederick L., Mech. Supt. and Engr., Haines, Jones & Cadbury Co., Philadelphia, Pa.

Lawson, James T., Ch. Operator, Public Service Elec. Co., Newark, N. J.

Leoni, Alfonso M., Ch. Engr., A. M. Leoni Mfg. Co., Inc., Philadelphia, Pa.

LIEBERMANN, PAUL B., Engr. of Tests, Hyatt Roller Bearing Co., Newark, N. J.

LONGINO, JAMES L., Secy. and Engr., Arkansas Lt. & Pwr. Co., Arkadelphia, Ark.

LUCK, GEORGE A., Deputy Chief, Mass. Boiler Insp. Dept., and Chairman Board of Boiler Rules, Boston, Mass.

LUCKE, HERBERT R., Mgr., De La Vergne Engine Co., Houston, Tex.

MACDONALD, JOHN W. F., Ch. Draftsman, Internatl. Engrg. Wks., Framingham, Mass.

MACY, NELSON, Pres., Corlies, Macy & Co., New York

MALI, FRANKLIN F., Mech. Engr., National Metal Molding Co., Ambridge, Pa.

MARBLE, EDWIN H., Pres., Curtis & Marble Mch. Co., Worcester, Mass.

MICKLE, ROBERT R., Pres., Mickle-Milnor Engrg. Co., Philadelphia, Pa.

MILNOR, THOMAS W., with Kline Hardware Co., Inc., Allentown, Pa.

MOORE, M. F., Asst. to Pres., Kewanee Boiler Co., Kewanee, Ill.

NEVILLE, WILLIAM J., with Chapman Valve Mfg. Co., Indian Orchard, Mass.

PARKE, FREDERIC H., Res. Engr., S. E. Dist., Westinghouse Air Brake Co., Pittsburgh, Pa.

PHELPS, PAUL, Genl. Mgr., The Challoner Co., Oshkosh, Wis.

PRATT, AUGUSTE G., Asst. to Pres., The Babcock & Wilcox Co., New York

RADFORD, GEORGE S., Production Engr., Remington Arms & Ammunition Co., Bridgeport, Conn.

ROBBINS, HARRIS A., Supt. Pwr., Brooklyn Rapid Transit System, Brooklyn, N. Y.

ROHRBACHER, WILLIAM, Boiler Insptr., Hartford Steam Boiler Inspt. & Ins. Co., Erie, Pa.

SACHS, DANIEL M., Vice-Pres. and Genl. Mgr., Northern Pipe Line Co., Oil City, Pa.

SACKETT, ROBERT L., Dean of Engrg., Penn State College, State College, Pa.

SAUERHERING, RICHARD P., Mech. Engr., Motor Dept., General Elec. Co., Pittsfield, Mass.

SEDGWICK, HARRY A., Asst. Supt., The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

SIGNAROWITZ, FERDINAND J., Designing Engr., Cameron Steam Pump Wks., Phillipsburg, N. J.

SKINNER, JAMES D., formerly in charge of Operating and Engrg. Depts., Northern Coal & Coke Co., Denver, Colo.

SPICER, CHARLES W., Master Mech., Fernwood Lumber Co., Fernwood, Miss.

STEM, FRANK B., Mech. Engr., Day & Zimmermann, Philadelphia, Pa.

STERLING, GEORGE R., Insptr., Hartford Steam Boiler Insp. & Ins. Co., Jersey City, N. J.

SWIFT, JOHN B., JR., Dist. Sales Mgr., American Rotary Valve Co., Chicago, Ill.

TAYLOR, FRANK W., Charge of Steam Turbine Erection, General Elec. Co.; Schenectady, N. Y.

THOMSON, P. FRESCOLN, Mgr., Thomson Tool & Supply Co., Indianapolis, Ind.

TURNER, RALPH E., Assoc. Editor, Practical Engineer, Chicago, Ill.

WEED, MARTIN B., Ch. Mech. Engr., Rock Island Oil & Mining Co., Dallas, Wyo.

WELD, LYDIA G. (Miss), in charge of Tracing Dept., Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

WESTERVELT, WILLIAM I., Major Ord. Dept., Supt. Watervliet Arsenal Shops, Watervliet, N. Y.

WESTON, BURT H., Instr. in Mech. Drawing and Mch. Design, The David Ranken Jr. Sch. of Mech. Trades, St. Louis, Mo.

WEYKER, WILLIAM J., Asst. to Ch. Engr., Commonwealth Edison Co., Fisk St. & Quarry St. Stas., Chicago, Ill.

WHELAN, WILLIAM R. F., Ch. Engr., Hudson River Mills, Internatl. Paper Co., Palmer, N. Y.

WIKSTROM, MALCOLM U., Genl. Supt., Pittsburgh Steel Products Co., Monessen, Pa.

WILLIAMS, WILLIAM H., Draftsman, Pittsburgh Seamless Tube Co., Beaver Falls, Pa.

WILSON, HENRY C., Cons. Engr., Tech. Dir., Ord. Dept., Westinghouse Elec. & Mfg. Co., New York

WOOD, JOHN T., Mech. Supt., Franklin Process Co., Providence, R. I.

WOOD, ROBERT, Cons. Engr., Nathan Mfg. Co., New York

WOODBURY, JOSEPH G., Dept. Supt., Remington Arms & Ammunition Co., Bridgeport, Conn.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ABELL, ASHEL C., Instr. in Mech. Engrg., Washington State College, Pullman, Wash.

BARTON, RAYMOND L., Draftsman and Checker, American Car & Fdy. Co., St. Charles, Mo.

BETTIS, ALEXANDER E., Mech. Engr., Kansas City Elec. Lt. Co., Kansas City, Mo.

BLACK, WILLIAM, Asst. Prof. of Steam & Gas Engrg., Univ. of Wis., Madison, Wis.

BUENSOD, ALFRED C., Mech. Engr., Internatl. Cigar Mchy. Co., Brooklyn, N. Y.

CARY, JAMES W., with Puget Sound Traction Lt. & Pwr. Co., Everett, Wash.

COLE, HAROLD R., Ch. Draftsman, A. Schrader's Son, Inc., Brooklyn, N. Y.

CREWSON, G. G., Mech. Engr., The Roessler & Hasslacher Chemical Co., Perth Amboy, N. J.

DANIELS, ARA M., Asst. Mech. Engr., Off. of Pub. Rds. and Rural Engrg., U. S. Dept. of Agri., Washington, D. C.

DAVIES, THOMAS R., Ch. Constr. Engr., Nitrate Agencies Ltd., Iquique, Chile, S. A.

DICKEY, ARTHUR J., Genl. Mgr., C. A. Dunham Co. Ltd., Toronto, Can.

DOYLE, MARTIN A., 2nd Lieut. of Engrs., U. S. Coast Guard Cutter "Mohawk," Sta. N., New York

GOBIN, ANDRE F., Mech. Engr., Ingram-Hatch Motor Corp., New York

GRIFFIN, PERLEY K., Mech. Draftsman, Stone & Webster Engrg. Corp., Cambridge, Mass.

HERRICK, DANIEL A., Supt., Julian D'Este Co., Boston, Mass.

HURXTHAL, ALPHEUS O., with The Lunkenheimer Co., Boston, Mass.

KEHOE, BASIL T., Genl. Foreman, Stirling Drum Dept., The Babcock & Wilcox Co., Barberton, Ohio

LAZEAR, WESTON B., Mech. Engr. New York Office, Stephens-Adamson Mfg. Co., New York

LEFFLER, LEO J., Secy., Chas. Leffler & Co., Brooklyn, N. Y.

LESERMAN, PHILIP, JR., Cons. Engr., also Owner, The Supervision Co., New York

MCLUNDIE, ARCHIBALD S., Mech. Engr. and Patent Atty., Chattanooga, Tenn.

O'CONNOR, JOHN B., Designer, Lyon Metallic Mfg. Co., Aurora, Ill.

PAPWORTH, WALTER A., Supt., Corona Typewriter Co., Groton, N. Y.

QUAYLE, LEROY A., Asst. Engr. of Pwr., Dept. of Public Utilities, Div. of Water, City of Cleveland, Ohio

SCHMIDT, JOHAN C. C., Engr. and Draftsman, Ransome Concrete Mchy. Co., Dunellen, N. J.

Scott, George W., Genl. Foreman, Scott & Sons' Co., Medford, Mass.

Scott, W. Doke, Engrg. Asst., Syracuse Ltg. Co., Syracuse, N. Y.

Smith, Walter J., Genl. Mgr., Lightwell Steel Sash Co., Newport, Del.

Streeter, Claude O., Asst. Sales and Cons. Engr., Graton & Knight Mfg. Co., Worcester, Mass.

Stringfellow, Henry A. Head of Dept. Civil Engrg., Mechs. Inst.. Rochester, N. Y.

Sweet, Steven H., The Hitchcock Gas Eng. Co., Bridgeport, Conn.

Thorpe, George H., Designing Engr., Millville Mfg. Co., Millville, N. J.

Udale, Stanley M., Lab. Engr., Holley Bros., Detroit, Mich.

Vallance, Alexander, Instr. in Theo. and Applied Mechs., Univ. of Ill., Urbana, Ill.

Walsh, William J., Plant Supt., Fayette R. Plumb, Inc., Philadelphia, Pa.

Wells, Meurice T., with Pratt & Inman, Worcester, Mass.

Williams, Richard C., with Buffalo Steam Pump Co., Buffalo, N. Y.

Wilson, Alfred B., Local Coml. Mgr., New York Telephone Co., Plainfield, N. J.

Young, John M., Mech. Engr., Otis Elevator Co., Buffalo, N. Y.

FOR CONSIDERATION AS JUNIOR

Agnew, James R., Ch. Engr., City of Clarksdale Municipal Pwr. Plant, Clarksdale, Miss.

Alden, Roger O., Toolmaker, Bausch Machine-Tool Co., Springfield, Mass.

Ballou, Joseph L., Insptr., Chicago Telephone Co., Chicago, Ill.

Bassett, Cyrus W., Engr., Elevator Supply & Repair Co., Chicago, Ill.

Blake, Frank C., Instr., Mech. Engrg., Brown Univ., Providence, R. I.

Brady, Laban J., Grad. Student 1915, Univ. Colo., Kansas City, Mo.

Burnell, Alfred E., Draftsman, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

Chace, Howard P., with Norton Grinding Co., Worcester, Mass.

Cole, Frank H., Head of Chem. Dept., Walworth Mfg. Co., Boston, Mass.

Colvin, James A., with Sauk Rapids Granite Co., Sauk Rapids, Minn.

Epstein, Meyer K., with Gilbert & Barker Mfg. Co., Springfield, Mass.

Fenn, John G., Supvrg. Insptr., London Guarantee & Accident Co. Ltd., New York

Fisher, Robert R., with Albaugh-Dover Co., Chicago, Ill.

Frauens, Frank H., Jr., Supvr. of Constr., W. B. Rollins & Co., Cons. Engrs., Kansas City, Mo.

Loeb, Alfred H., Rolled Wheel Dept., Midvale Steel Co., Philadelphia, Pa.

Luehrmann, Hugh, with The Babcock & Wilcox Co., Cincinnati, Ohio

Main, Charles C., Jr., with Brunner Mfg. Co., Utica, N. Y.

Miller, Lyman H., with American Steel & Wire Co., Worcester, Mass.

Mueller, Jacob L., Experimental Engr., Springfield Facing Co., Springfield, Mass.

Neff, Russell M., with David Luptons' Sons Co., Philadelphia, Pa.

Noble, Robert E., Designing Mech. Engr., Mesta Mch. Co., Pittsburgh, Pa.

Patten, Ernest L. O., Mech. Engr., Katahdin Pulp & Paper Co., Lincoln, Me.

Pearce, Edwin S., Specl. Engr., Chicago, Cleveland, Cincinnati & St. Louis Rwy., Indianapolis, Ind.

Perry, Ralph H., Mech. Engr., Katahdin Pulp & Paper Co., Lincoln, Me.

Renton, James L., Shop Foreman, Ewa Plantation Co., Ewa, Hawaii

Richon, Jules L., Betterment Dept., Robert Gair Co., Brooklyn, N. Y.

Rowlands, Richard A., Engrg. Dept., The Babcock & Wilcox Co., Barberton, Ohio

Rubin, Harry E, with The National Dry Kiln Co., Indianapolis, Ind.

Schlenker, Rudolf P., Mech. Draftsman, Bath Iron Wks., Bath, Me.

Schlank, Elias, Engr., M. W. Kellogg Co., Jersey City, N. J., and New York

Schmidt, Francis W., Engr., West Penn Traction Co., Pittsburgh, Pa.

Schneider, Louis J., with Hyatt Roller Bearing Co., Detroit, Mich.

Sheatsley, Paul W., Grad. 1915, Ohio State Univ., Columbus, Ohio

Voigt, Louesther S., Foreman Reinforced Concrete Constr., with Wm. E. Cory, Civ. Engr., Sedalia, Mo.

Wieber, George A., Student App., Westinghouse Mch. Co., East Pittsburgh, Pa.

Young, Charles M., Engr. Draftsman, Thomas Potter Sons & Co., Inc., Philadelphia, Pa.

## APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

Nichols, Frederick C., Asst. Engr., The Panama Canal, Balboa Heights, C. Z.

PROMOTION FROM JUNIOR

Gilman, Franklin W., Testing Engr., Sanford Riley Stoker Co. Ltd., Worcester, Mass.

Martin, Edward J., Asst. Supt., Hopkins & Allen Arms Co., Norwich, Conn.

Renner, Roland B., Charge of Engrg., Jeffrey Mfg. Co., New York

## SUMMARY

| | |
|---|---|
| New Applications | 165 |
| Applications for change of grading: | |
| Promotion from Associate-Member | 1 |
| Promotion from Junior | 3 |
| | 169 |

# ICE-MAKING AS A BY-PRODUCT OF CENTRAL STATIONS

BY HEYWOOD COCHRAN,[1] CHICAGO, ILL.

Non-Member

ALTHOUGH ice plants have been operated in connection with electric light plants for a considerable time, it is only within the past five years that the possibilities for profit in such a combination are beginning to be appreciated. These ice plants may be conducted in either of two ways: *First,* as the property of the central station, in which case they are usually located adjacent to the power plant; *Second,* privately owned, purchasing current or steam from the central station. The latter are usually motor driven compression plants, located at the point best adapted for the distribution of ice.

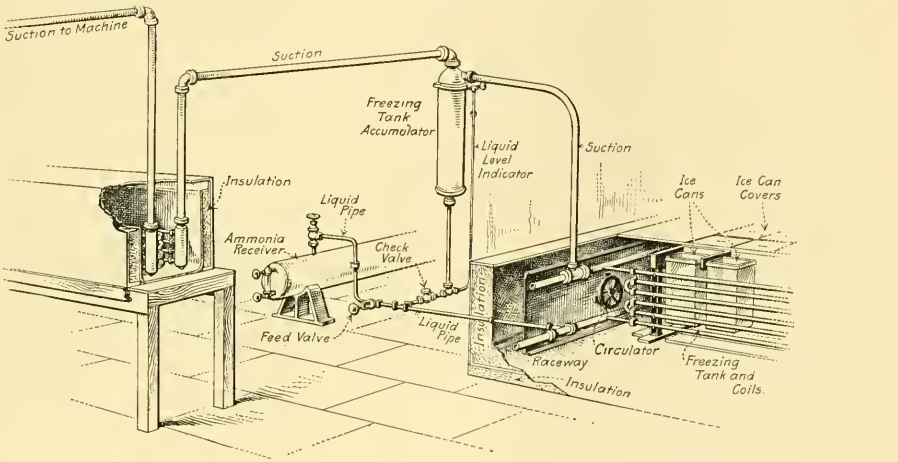



FIG. 1 DIAGRAMMATIC VIEW OF A SECTION OF A MODERN ICE TANK OF THE FLOODED TYPE

One point of difference between electric light and ice plants is the limit of size for economical distribution. For the former this is indefinite, but the latter soon reach a size where the cost of distribution more than offsets the saving from a central plant. There are in operation plants of 300 to 500 tons capacity, but individual plants of from 80 to 150 tons capacity are preferable. Except for the cost of distribution, however, a plant owned by a central station if properly designed can make ice cheaper than any ice plant in the second class or any other privately owned plant.

In order to explain why certain kinds of ice machines are better adapted for the first class and others for the second, a brief description of the methods of ice manufacture will be given. While there are a number of different refrigerants, only ammonia will be considered, as it can be used in both compression and absorption ice machines. Ammonia, as is well known, is a gas at atmospheric pressure and all ordinary temperatures, but it may be liquefied by compression, the pressure required depending upon the amount of condensing surface, type of condenser and temperature and amount of condensing water available. The liquid, usually known as "liquid anhydrous" (although it is not always anhydrous), must then absorb heat before it can again become a gas.

Fig. 1 shows a section of a modern ice tank of the "flooded" type. The liquid anhydrous passes from the ammonia condensers into the receiver on the left and then enters the coils in the tank at the bottom, through a valve known as the "expansion valve." The ice cans are filled with water and the surrounding space with brine. The liquid anhydrous in the coils absorbs heat from the brine, which in turn absorbs heat from the water in the cans, taking up 142 B. t. u. from every pound of water at 32 deg. in order to form ice at the same temperature. The resultant gas is removed from the coils to be recondensed and it is in this process alone that the absorption and compression systems differ.

While in the compression system the ammonia gas is mechanically sucked out of the coils by a compressor, in the absorption system, it is sucked out by its strong attraction for water, making aqua ammonia. An absorption machine involves the use of heat exchanging apparatus comprising absorber, generator, etc., as indicated in Fig. 2, which shows a typical absorption machine of the double pipe and tubular type. Here the expanded gas is to be removed from brine cooler coils. The absorber, which is the heart of the system, is built like a horizontal tubular boiler, with 2 in. tubes through which cooling water passes. Weak aqua, which has had a part of its gas driven off, enters the top. On the suction stroke of the machine the gas bubbles up through this weak aqua, changing it into strong aqua, which is pumped into the ammonia boiler or generator, where steam passing through coils drives off the gas and produces sufficient pres-

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Presented at the Chicago local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, March 19, 1915.

sure to condense it. The rectifier is a drier and the exchanger is the feed water heater of the system. The aqua pump, which is the only moving part, requires about 1/10 h.p. per ton of ice and can be driven either by steam or motor. The action of the generator in this case takes the place of the compression stroke. Instead of having only one cycle as in the compression system, there are two, the strong and weak aqua cycle being the second.

Thus the compression machine requires power only while the absorption machine requires practically heat only, and a highly economical ice plant can be made by a combination of the two systems, especially if raw water ice is made as in the case of the electrically driven compression plant. With cold condensing water, say under 70 deg., it is possible to use exhaust steam at 3 lb. pressure in the generator. This steam is condensed, furnishing a portion of the distilled water required for making ice. About 55 to 60 lb. of steam per hour per ton of ice are required for this purpose. With condensing water of 90 to 95 deg. it is not possible to run on less than from 20 to 25 lb. exhaust steam pressure, because of the high condensing pressures necessary. Such pressures would seem prohibitive and yet a plant will be described later which is proving very economical under those conditions.

The absorption machine is the ideal one for warm water conditions when properly designed. Just as it takes very little more coal to carry 125 lb. pressure than 100 lb. (less than 1 per cent), it takes comparatively little more steam in the generator to produce 200 lb. pressure than it does 150 lb. The increase in power required for a compression machine, however, is very marked. An electrically driven compression plant will require from 43 to 70 kw-hr. per ton of ice per day, depending upon its size and other conditions. The former figure can hardly be called normal. At 1 cent per kw-hr. the power costs per ton will usually average between 50 and 60 cents. Table 2 gives figures showing the operating cost of compression machines using various sources of power including electricity. This gives $58\frac{1}{2}$ kw-hr. as the amount of current required for all purposes.

From the central station manager's standpoint in the larger cities, such as Chicago, the privately owned, electrically-driven ice plant is the proper combination, while in the smaller cities, he will find it much more profitable to own the ice plant direct. Whether it is more profitable in the larger cities from the ice plant manager's standpoint to purchase current at a power cost of 50 cents per ton or over is very questionable and will depend largely upon circumstances. Some figures from an independent exhaust-steam ice plant will be of interest.

Table 1 gives the coal cost per ton on ice made in such a plant with coal at $1.80 per ton. The coal used was of various kinds, although that at $1.80 per ton was Indiana No. 4. All ice was made from distilled water. The coal cost per ton is only 20 cents. Adding the fireman's wages and interest and

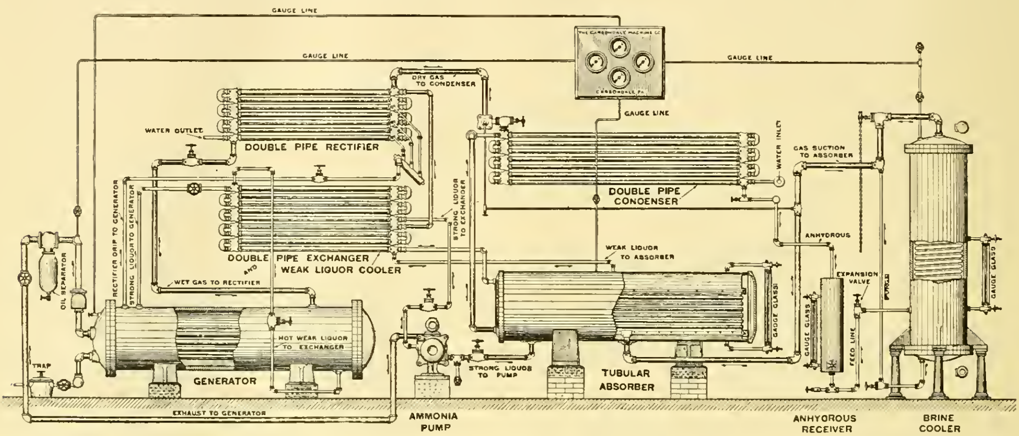


FIG. 2 DIAGRAM SHOWING GENERAL ARRANGEMENT OF A TYPICAL ABSORPTION REFRIGERATING MACHINE OF THE TUBULAR TYPE

TABLE 1 COAL AND ICE RECORDS, MUNCIE ICE & COAL CO. MUNCIE, IND.

| Aug. 1912 Date | Day or Night | Kind of Coal | No. 400 lb. Cakes | Pounds Ice Made | Pounds Coal Burned | Ratio | Ave. Ratio | Ave. Fuel Cost |
|---|---|---|---|---|---|---|---|---|
| 18 | Day | Indiana No. 4 | 152 | 60800 | 6860 | 8.7 | 8.7 | |
| 18 | Night | at $1.80 per ton | 141 | 56400 | 6491 | 8.7 | 8.7 | |
| 19 | Day | " | 150 | 60000 | 6357 | 9.4 | 8.93 | |
| 19 | Night | " | 150 | 60000 | 6896 | 8.7 | 8.88 | |
| 20 | Day | " | 150 | 60000 | 6685 | 9.0 | 8.9 | |
| 20 | Night | " | 150 | 60000 | 6476 | 9.2 | 8.95 | |
| 21 | Day | " | 150 | 60000 | 7101 | 8.4 | 8.87 | |
| 21 | Night | " | 150 | 60000 | 6689 | 9.0 | 8.89 | |
| 22 | Day | " | 150 | 60000 | 6975 | 8.6 | 8.86 | |
| 22 | Night | " | 150 | 60000 | 6661 | 9.0 | 8.87 | |
| 23 | Day | " | 150 | 60000 | 6945 | 8.6 | 8.84 | |
| 23 | Night | " | 141 | 56400 | 6805 | 8.3 | 8.8 | |
| 24 | Day | " | 160 | 64000 | 6937 | 9.2 | 8.83 | |
| 24 | Night | " | 154 | 61600 | 6625 | 9.3 | 8.86 | |
| 25 | Day | " | 145 | 58000 | 6863 | 8.7 | 8.85 | |
| 25 | Night | " | 150 | 60000 | 6673 | 9.0 | 8.86 | |
| Average | | | 149½ | 59825 | 6752 | | 8.86 | $0.203 |

depreciation on the boiler plant, the total power cost should not exceed 35 cents.

It is entirely possible, however, in a properly designed compression and absorption plant, say of 80 tons capacity, with a 20 ton machine of the former type and a 60 ton of the latter, to make ice at a fuel cost even lower. In this case, there should be two 40 ton tanks, the compression machine being used on one-half the coils of one tank and the absorption machine on the others. The exhaust from the compression engine and auxiliaries furnishes the 3600 lb. of steam per hour required for the generator and the absorption machine, making raw water ice with coal at $2.00 per ton, at an evaporative efficiency of only 6 to 1; 6½ tons are required and the fuel cost is 16 cents per ton. Such an 80 ton plant could be run on a 125 h.p. boiler and with a second boiler in reserve, the cost, including interest and depreciation, etc., and labor will hardly be more than 30 cents per ton, if that. There will be plenty of distilled water for filling cores, and distilled water ice can be made at a slightly increased cost.

Of course, if a suitable neighbor could be found requiring a certain amount of power and heat and having no use for the exhaust steam, a straight 80 ton absorption machine could be installed. By using the expansive force of the 4800 lb. of steam per hour, required by the generator, in an economical unaflow engine, current could be sold, not bought, which would further reduce the operating cost.

To show the possibilities for profit in a properly designed combination plant, owned by a central station, reference will be made to a plant in a southern city of about 50,000 inhabitants, where the conditions are so trying that if a combination plant can prove profitable there, it would anywhere. This plant was installed in 1912, under the direction of Sargent & Lundy, consulting engineers of Chicago, and has proved satisfactory to all concerned.

The old company had been in the ice business for a number of years, having a 50 ton compression machine with two 25 ton tanks, each containing 412 - 300 lb. cans. At one end of the old building they also had a 2,000 ton storage house which had never been insulated or used. In addition they owned a second compression ice plant with independent steam plant, of 25 tons capacity, located a mile or more away and operated as a separate unit from May to September. A spray pond was used for cooling condensing water for both the condensing engine and the ice machine. The fact

TABLE 2 COST OF MANUFACTURING RAW-WATER ICE—100 TONS CAPACITY—VARIOUS SOURCES OF POWER

*(From General Electric Review, July 1914)*

| | Motive Power | Using | h.p. | Total h.p.-Per hr. Day | Fuel per h.p. | Fuel or Power Per Day | Unit Cost of Fuel | Fuel Cost per Day | Tons of Ice per Unit of Fuel | SUNDRY COSTS | | | LABOR COST | | | | | Total Cost per Day | Cost per h. p. of Power Plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Oil Waste. Etc. | Ammonia | Calcium | 1 Day Engineer | 1 Night Engineer | 4 Ice Pullers | 1 Extra Man | 2 Firemen | | |
| 1 | Simple Steam Engine | Bituminous Coal | 367 i.h.p. | 8808 | 3½ lb. | 15.4 tons | 2.00 tons<br>2.50 tons<br>3.00 tons | $30.80<br>38.50<br>46.20 | 6.38 Tons Ice per Ton of Coal | 2.00 | 2.50 | 0.50 | 5 00 | 3.25 | 8.00 | 2 00 | 5.00 | $59.05<br>66.75<br>74.45 | $32.00 |
| 2 | Compound Condensing Engine | Bituminous Coal | 375 i.h.p. | 8952 | 2 lb. | 8.95 tons | 2.00 tons<br>2.50 tons<br>3.00 tons | 17.90<br>22.38<br>26.85 | 11.15 | 3.50 | 2.50 | 0.50 | 5.00 | 3.25 | 8.00 | 2.00 | 5.00 | 46.15<br>50.63<br>55.10 | 40.00 |
| 3 | Producer Gas Engine | Bituminous Coal | 360 b.h.p. | 8640 | 1¼ lb. | 5.4 tons | 2.00 tons<br>2.50 tons<br>3.00 tons | 10.80<br>13.50<br>16.20 | 18.5 | 3.50 | 2.50 | 0.50 | 6.00 | 4 00 | 8.00 | 2.00 | 4.00 | *41.30<br>44.00<br>46.70 | 65.00 |
| 4 | Producer Gas Engine | Anthracite Coal | 360 b.h.p. | 8640 | 1 lb. | 4.31 tons | 3.00 tons<br>3.50 tons<br>4.00 tons<br>4.50 tons<br>5.00 tons<br>5.50 tons<br>6.00 tons | 12.93<br>15 09<br>17.24<br>19 40<br>21.55<br>23.71<br>25 86 | 23.2 | 3.50 | 2.50 | 0 50 | 6.00 | 4 00 | 8 00 | 2.00 | 4 00 | 43.43<br>45.59<br>47.74<br>49.90<br>52.05<br>54.21<br>56.36 | 65.00 |
| 5 | Producer Gas Engine | Lignite | 360 b.h.p. | 8640 | 1¾ lb. | 7.56 tons | 2.00 tons<br>2.50 tons<br>3.00 tons | 15.12<br>18 90<br>22 68 | 13.2 | 3.50 | 2.50 | 0.50 | 6.00 | 4.00 | 8.00 | 2.00 | 4.00 | 45.62<br>49.20<br>53.18 | 65.00 |
| 6 | Gas Engine | Natural Gas 1050 B.t.u. Value | 360 b.h.p. | 8640 | 10 cu. ft. | 86400 cu. ft. | 0.20 per M<br>0.25 per M<br>0.30 per M<br>0.35 per M | 17.28<br>21.60<br>25.92<br>30.24 | 864 cu. ft. gas req'd per Ton of Ice produced | 3.50 | 2.50 | 0.50 | 6.00 | 4.00 | 8 00 | 2.00 | | 43.78<br>48.10<br>52 42<br>56.74 | 35.00 |
| 7 | Oil Engine | Fuel Oil | 360 b.h.p | 8640 | 0.075 gal. | 648 gal. | 0.02½ gal.<br>0.03 gal.<br>0.03½ gal.<br>0.04 gal. | 16.20<br>19.44<br>22.68<br>25.92 | .155 Tons Ice per Gal. of Oil | 3.50 | 2.50 | 0.50 | 6.00 | 4 00 | 8.00 | 2.00 | 4 00 | 46.70<br>49.94<br>53.18<br>56.42 | 40.00 to 60 00 |
| 8 | Motor | Electricity | 327 on wire | 7848 | 0.746 kw. | 5854 kw. | 0.00½ kw.<br>0.00⅝ kw.<br>0.00¾ kw.<br>0.00⅞ kw.<br>0.01 kw. | 29.27<br>36.48<br>43.90<br>51 23<br>58.54 | 58.54 kw-hr. req'd per Ton of Ice produced | 2.00 | 2.50 | 0.50 | 5.00 | 3.25 | 8.00 | 2.00 | | 47.51<br>59.63<br>67.15<br>74 48<br>†81.79 | 16.00 |

Water estimated at 70 deg. fahr. Suction pressure 15 lb. Power included for pumping water with 60 foot head. * Minimum.

Condenser pressure 185 lb. Ammonia used as refrigerant. † Maximum.

Above costs do not include interest on investment, depreciation, taxes, insurance, management or any other fixed charges. Power is based on summer conditions. Less power will be required if yearly average is figured on. Oil engine fuel requirements based on engines of Diesel type.

that the temperature of this water reached 95 deg. and sometimes over, had greatly reduced the output of the 50 ton plant as well as increased the cost of manufacture. In fact, hardly more than 38 to 40 tons of ice had been made daily on the two tanks previously mentioned, and the operating cost was considerably over $2.00 per ton. It is only fair to say, however, that as the new owners contemplated a change, the plant was not in as good condition as it should have been.

It was decided to increase the output to 100 tons and the original plans contemplated the addition of 50 tons more tank capacity and either electrically driven compression machines at the old plant, or compound condensing machines of 100 tons capacity at the new. The engineers, however, wisely decided to insulate the ice storage house which would give 40 tons extra capacity daily for fifty days, during the summer peak, and they put in an exhaust steam Carbondale machine of the atmospheric type, guaranteed to make 60 tons of ice on the two tanks and cool the storage house. The old 25 ton plant was abandoned and sold. The condensers, absorbers, weak liquor coolers and rectifiers are located on the boiler house roof of the new plant. In this connection, it may be of interest to know that this exhaust steam machine was added without increasing the size of the power plant building, while same would have had to be extended at a cost of $12,000.00 if a compound condensing compression machine had been selected. Preliminary estimates showed that ice could be made in this plant at an operating cost not exceeding 45 cents per ton.

Fig. 4 is an interior view of the turbine room in the new power house, showing one of the two 2500 kw. turbines which, of course, is run condensing. In the foreground is a 75 h.p. Terry turbine direct connected to a centrifugal water

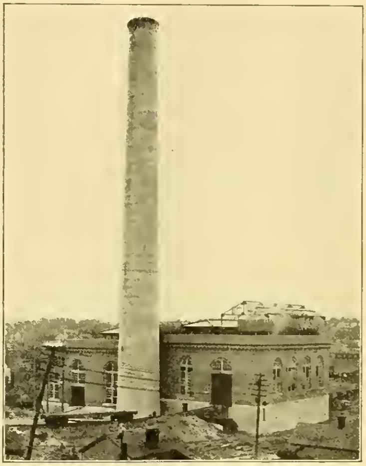

Fig. 3 Exterior of Power Plant showing Location of Atmospheric Apparatus on the Roof

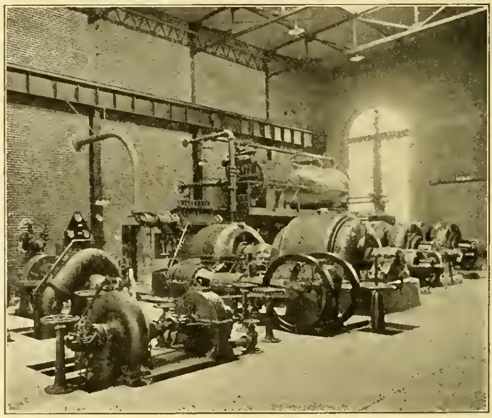

Fig. 4 Interior of the Turbine Room showing Ammonia Generator on Gallery

TABLE 3 ICE PRODUCED AND SOLD BY A COMPANY IN A SOUTHERN CITY DURING THE PAST SEVEN YEARS

| | Tons Manufactured | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 |
| January | 124 | 292 | .. | 100 | 289 | 110 | 1497 | 728 |
| February | 158 | 263 | .. | 211 | 330 | 162 | 1437 | 1148 |
| March | 1170 | 681 | 121 | 464 | 393 | 261 | 1215 | 2293 |
| April | 1604 | 778 | 1052 | 612 | 498 | 246 | 1236 | 2209 |
| May | 1177 | 1248 | 1513 | 799 | 1106 | .. | 1959 | 1876 |
| June | 1277 | 1991 | 1393 | 1051 | 1859 | .. | 2012 | 1977 |
| July | 2219 | 1995 | 432 | 1117 | 1747 | .. | 2134 | 2125 |
| August | 2110 | 1901 | 1114 | 1873 | 1389 | 1333 | 2178 | 2156 |
| September | 1728 | 1666 | 400 | 1073 | 1238 | 1836 | 1773 | 2035 |
| October | 699 | 776 | 112 | 902 | 977 | 1462 | 1452 | 2173 |
| November | .. | 568 | 567 | 353 | 382 | 1068 | 814 | 1845 |
| December | 83 | 755 | 291 | 301 | 320 | 1250 | 801 | 1462 |
| Total | 12349 | 12814 | 6997 | 8856 | 10528 | 7728 | 18508 | 22027 |
| Increase | .. | 465 | .. | 1859 | 1672 | .. | 10780 | 3519 |
| Decrease | .. | .. | *5817 | .. | .. | **2800 | .. | .. |
| Per Cent Increase | .. | 3 7 | .. | 26 | 19 | .. | 139 | 19 |
| Per Cent Decrease | .. | .. | 45 | .. | .. | 26 | .. | .. |

| | Tons Sold | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1907 | 1908 | 1909 | 1910 | 1911 | 1912 | 1913 | 1914 |
| January | 431 | 280 | 341 | 228 | 301 | 129 | 1256 | 714 |
| February | 251 | 248 | 321 | 182 | 308 | 133 | 943 | 518 |
| March | 592 | 548 | 406 | 423 | 346 | 223 | 991 | 707 |
| April | 527 | 700 | 609 | 532 | 486 | 530 | 1170 | 966 |
| May | 1119 | 1167 | 921 | 823 | 1363 | 971 | 1743 | 1603 |
| June | 1291 | 1797 | 1290 | 1199 | 1721 | 1223 | 2014 | 2964 |
| July | 2212 | 2011 | 381 | 1260 | 1748 | 1603 | 2682 | 2137 |
| August | 1976 | 2031 | 1541 | 1691 | 1800 | 1529 | 2565 | 3229 |
| September | 1634 | 1797 | 552 | 936 | 1522 | 1625 | 2027 | 2570 |
| October | 843 | 980 | 218 | 849 | 948 | 1107 | 1401 | 1698 |
| November | 484 | 564 | 524 | 408 | 327 | 825 | 725 | 1271 |
| December | 347 | 458 | 282 | 263 | 276 | 774 | 773 | 777 |
| Total | 11707 | 12581 | 7386 | 8794 | 11145 | 10672 | 18290 | 19154 |
| Increase | .. | 874 | .. | 1408 | 2351 | .. | 7618 | 864 |
| Decrease | .. | .. | 5195 | .. | .. | 473 | .. | .. |
| Per Cent Increase | .. | 7.4 | .. | 19 | 26 | .. | 71 | 4 |
| Per Cent Decrease | .. | .. | 41 | .. | .. | 4 | .. | .. |

* Enlargement of ice storage necessitated purchase of abnormal amount of ice in order that the house would be filled before the summer season.

** Plant No. 1 broken down and tank room being overhauled. Plant No. 2 was inoperative necessitating purchasing practically entire supply.

circulating pump, which was designed to run to its capacity with 200 lb. steam pressure and 25 lb. back pressure; under these conditions, it was guaranteed to use 70 lb. of steam per h.p.-hour, just 20 lb. more than if it had exhausted at atmospheric pressure into the feed water heater. This is somewhat more steam than the generator requires, and the excess is used in the heater.

Fig. 5 is a near view of the ammonia generator, showing the aqua pumps beneath and the aqua receiver at one side. One of these small pumps is capable of making 75 tons of ice, is automatically controlled and requires little attention. In fact, outside that of pulling and storing the ice, the labor cost in the plant is practically eliminated. The exchangers of the vertical shell type are on the other side of the wall, back of the boilers. All the rest of the machine is on the boiler house roof.

Fig. 6 shows this atmospheric apparatus. There are 28 combined condenser and absorber stands of which the upper ten pipes are condensers and the lower twelve absorbers. The rectifiers and weak liquor coolers can be seen in the rear. The weak liquor enters the mixer through a jet helping to pull in the gas. During the winter one-half of these stands will make capacity and only 55 lb. pressure is required on the generator, materially reducing the steam consumption.

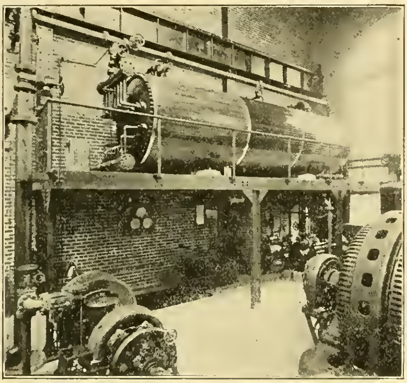

Fig. 5 Near View of the Ammonia Generator showing Aqua Pumps underneath

Table 3 shows the ice produced and sold for the past seven years by this company, the new machinery having been started August 10, 1912. In this connection, it should be remembered that up to 1912 the figures include the output of the 25 ton independent plant.

In January 1914 the roof of the storage house was raised so that ice can be piled 60 ft. high, increasing the capacity to 5,000 tons. In spite of this extra refrigerating load, the plant averaged 70 tons of ice during the hot summer months and 60 tons for 365 days. The credit of this is due, not only to the machine, but to the fact of unusually capable management.

Table 4 shows the output and operating cost for 1914. Even with 95 deg. water and a tank 500 ft. away from the machine the entire average operating cost for the year is less than the power cost alone in the privately owned electrically-driven compression plant. Table 5 shows the detail of the 41 cents per ton operating cost.

As a rule, it is better to figure on obtaining steam for the generator from one or more of the auxiliaries as in this case. If at times the supply is insufficient, live steam can be admitted through a pressure reducing valve, but it doesn't pay to put back pressure on a large engine for a small ice plant.

With well water, it is entirely possible to operate the generator on from $\frac{1}{2}$ to 3 lb. pressure. While it is perhaps advisable to use the exhaust from the auxiliaries in condensing plants in all cases, it is entirely possible to bleed sufficient steam from an intermediate stage of a condensing turbine. A 2500 kw. turbine, running at full load with $27\frac{1}{2}$ in. vacuum, used 14.85 lb. of steam per kw.-hr. When the turbine was operated under the same conditions, except that 5000 lb. of steam was extracted per hour, at from 2 to 5 lb. pressure, 16.32 lb. was used. This is an increase of 3675 lb. per hour and, as this 5000 lb. of steam so extracted will make 85 tons of ice, the extra steam would amount to 43 lb. per ton of ice per hour. This is over twice the extra steam required from the plant just described. If the above engine is operated at half load, and 5000 lb. of steam per hour is extracted, 16.8 lb. will be used. This will be 2437 lb.

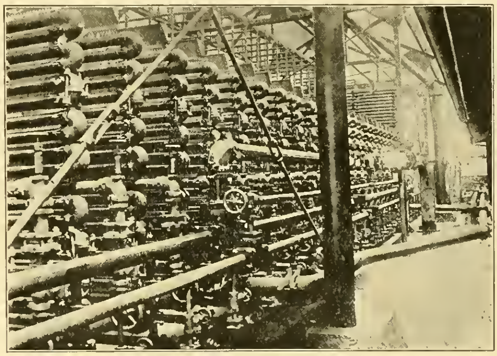

Fig. 6 View of the Atmospheric Arrangement of Condenser and Absorber Stands

TABLE 4 PRODUCTION DATA FOR CALENDAR YEAR 1914

| Month | Tons Mfg. | Cost per Ton Mfg. |
|---|---|---|
| January | 728 | $.35 |
| February | 1148 | .33 |
| March | 2293 | .27 |
| April | 2209 | .33 |
| May | 1876 | .46 |
| June | 1977 | .42 |
| July | 2125 | .45 |
| August | 2156 | .42 |
| September | 2035 | .42 |
| October | 2173 | .451 |
| November | 1845 | .461 |
| December | 1462 | .4792 |
| Total, | 22027 | $ 4062 |

of steam extra or $28\frac{1}{2}$ lb. per ton of ice per hour. It is, therefore, more economical to bleed such a condensing turbine at half rather than full load, but in neither case as economical as where exhaust is taken from non-condensing auxiliaries.

If the turbine had been running at full capacity condensing and the current used for driving an electrically-driven compression machine, about the same amount of extra steam would be taken from the boilers to make 85 tons of ice as would be required for an absorption machine of this capacity bleeding steam from the turbine. However, in the first case, the output of the turbine would be decreased by the amount of current used, while in the latter its entire capacity would be available for commercial purposes.

In conclusion, it may be said that central station managers, owning their own ice plants, where properly designed, are finding such plants far more profitable than the lighting plant itself. In fact, in some of the smaller cities, where the light plant was operated alone at a loss, the combination has turned the same into a source of profit. In many small towns the water and light plants are combined, in which cases the water is first used for the ice machine and afterwards turned into the city mains. There can be no question about the future of the properly designed combination plant.

TABLE 5 ICE STATEMENT FOR CALENDAR YEAR 1914

| | Year Ending 12-31-14 | Per Ton Made |
|---|---|---|
| Station wages | \$2793 38 | .13 |
| Fuel | 2498 11 | .11 |
| Water | 910.22 | .04 |
| Lubricants | 36 90 | ... |
| Supplies and expenses | 315 86 | .01 |
| Salt and ammonia | 424.91 | .02 |
| Maintenance buildings | 239 07 | .01 |
| Maintenance equipment | 521 25 | .03 |
| Power bought | 1208.10 | .06 |
| Total production | \$8947.80 | .41 |

## DISCUSSION

E. W. Lloyd[1] in discussing this paper said that three or four years ago when it became necessary for the central stations in Chicago to secure additional power loads in order to meet a new rate schedule, the refrigerating business presented itself as the most promising. Experience has justified this promise and in the past three years the number of plants thus operated has been increased from one to eighteen, and at present a third of a million tons of ice, or ten per cent of the city's total requirements, is being made with central station power. The chief interest is in raw water ice plants which are the best where the public water supply is pure. The annual load factor is about 45 per cent, though in exceptional cases it may rise to 65 per cent. The kilowatt hours per ton is quite variable, depending somewhat on the size of the cans. Experiments are now being made to determine the best ratio. We sell power for ice making at one cent per kw.-hr., which is feasible on account of the low increment cost of taking on the business of this class.

[1] Commonwealth Edison Co., Chicago.

# SOME ENGINEERING PROBLEMS ARISING IN THE TRANSPORTATION OF NATURAL GAS

BY JAS. P. FISHER, BARTLESVILLE, OKLA.

Member of the Society

NATURAL gas occurs in certain portions of certain strata of the earth's surface in areas of comparatively limited extent. It is used as fuel, for the most part, in centers of population and industrial activity. The fields where the gas is found usually happen to be at considerable distances from the points of consumption, making it necessary to lay pipe lines for transporting the gas. The designing, building and operation of these transportation systems give rise to many problems of an engineering nature.

In the earlier stages of the industry, the greatest difficulty was experienced in constructing a pipe line sufficiently good and cheap to make the commercial transportation of gas feasible for any great distances. As better pipe line, pipe couplings, compressing equipment and measuring equipment have been developed, it has been made possible to transport gas successfully over greater and greater distances. The limits in improvement in equipment and in knowledge of conditions have not yet been reached by any means, so that the present distances of transportation are in no way final.

In the beginnings of the industry no supply of suitable pipe was available, and the joints between sections were so imperfect and prone to leak that it was found commercially impracticable to transport gas through a pipe for more than a very few miles. Various types of pipe lines were tried. Some lines were laid with cast iron pipe, with bell and spigot joints calked with lead. These lines were fairly good for moderate pressure, but were very expensive to lay. Their high cost and the proportionately low pressures permissible made them unsuitable for any great length.

Lines of steel or wrought iron pipe with screw joints were the first used to any large extent. In some of the earlier lines, the joints were made with a straight thread; but it was very soon found that the taper thread was greatly superior, both in strength and tightness. Some very extensive transportation systems were laid with pipe joined in this way, but a number of serious difficulties arose, the greatest of which was that of making a line reasonably free from leakage. This leakage became greater with increase in length of line, and also with increase in pressures carried, and put a commercial limit on the distance that it was profitable to transport gas.

When it was necessary to increase the carrying capacity of a line, pipe of larger diameter was laid without attempting to materially increase the pressure carried. This led, in some instances, to lines of enormous diameter. One line was laid into Pittsburgh 36 in. in diameter, of steel riveted pipe joined by flanges throughout its length. Such construction was exceedingly costly; and, when it is remembered that the field to which a line was laid might not last more than a few years, it is seen that a better arrangement

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of pipe line was very badly needed. It was not found practicable to make threaded joints in pipe larger than 12 or 14 in. in diameter, and even in pipe of this size it was found to be difficult to make tight joints.

Several different types of wrought iron pipe joints made by calking with lead were tried. Lines laid with such joints were tight at first, but any motion of the pipe from settling of the soil or temperature changes was found to make them leak badly.

Temperature changes were also found to be a destructive element in a line of pipe connected by threaded joints. Lines laid in the summer often pulled apart in the winter. Where such joints are now used, the lines are laid in cold weather if possible.

To meet these difficulties a new type of coupling was developed, consisting of a center piece, which slipped over the ends of the two lengths of pipe to be joined, two glands or end rings, two rubber packers, and connecting bolts between the two end rings, the whole forming a double stuffing box arrangement. This coupling proved to possess many advantages over any form of joint previously used, and with it lines that were very nearly free from leaks, if sufficient care was taken in their construction, were found possible. Lines could also be made of lighter pipe and still carry the same or higher pressures than was possible with the threaded joint. This improvement has greatly increased the distance it is possible to transport gas profitably; and, although the joint has many grave weaknesses, it is the best available at the present time.

Recently there have been some short lines laid in which the pipe was welded together end to end. This practice is too new to prove its success, but it seems to promise the solution of difficulties due to leakage and deterioration of the rubber-packed joints now commonly used. Like pipe joined by screw joints, the line will be subjected to heavy strains due to temperature changes, and it is likely that special provisions in expansion joints will have to be made for this condition.

In the early days, the natural pressure of the gas as it occurred in the fields was the source of power used for its transportation. As the fields neared exhaustion, or when the distances from the fields to the points of consumption were too large, the pressure fell too low, and it became necessary to increase it artificially by means of compressors of one type or another. In many of the earlier plants attempts were made to locate these compressors in the towns and draw the gas through the lines by suction. As could have been easily predicted theoretically, these attempts failed, and it became the practice to locate the stations in or near the fields. At the present time practically every gas transportation company has to keep up a system of compressing stations in order to properly maintain and control the amount of gas passing through its lines.

Most of the larger natural gas systems of the country have been the result of a process of evolution in which lines were extended farther and farther to reach one field after another, and in which one compressing station after another has been built, usually for the purpose of putting gas from a declining local field into the main trunk line. Another factor in this evolution has been the necessity of small companies combining in order to be able to go to greater distances for a common additional supply when the old sources of supply were exhausted. As conditions have changed, some of the equipment becomes useless in its present location, and sometimes it is possible to so alter lines as to utilize old equipment for a new purpose.

The Cushing field is one of the main sources of supply in the mid-continental region. When first developed this promised to be a long-lived source of supply. At that time, however, the gas was found mostly in the Wheeler Sand, at a depth of about 1500 ft., and some oil was found with it. The presence of oil in a field is always somewhat of a menace to the life of the field as a gas supply. This is largely because it is cheaper and easier to produce the oil and allow the gas to waste to atmosphere. When oil wells are so situated as not to be convenient to a gas line, the gas is not marketable, and is considered as a by-product of small value by the oil man. In a great many instances oil can be produced without pumping by simply allowing the gas pressure to blow it out.

In the Cushing field, oil and gas were discovered in a deeper sand several months after the taking of gas from the field had been begun. This caused an exceedingly active development of the deeper sand for oil, and enormous quantities of gas were allowed to waste to the air. Not only this, but in a great many instances the wells were so carelessly cased and packed that the higher pressure gas in the deep sand followed up around the casing to the lower pressure strata above, where it was dissipated and was no longer available for commercial purposes. By proper means, it is possible to drill the oil wells and produce the oil with scarcely any waste of gas, but it costs more.

It is estimated that the gas escaping from the Cushing field is about 400,000,000 cu. ft. per day, or about 11,000 tons per day. This would be equivalent in fuel value to a train load of coal of 300 to 400 cars of average capacity. Of the gas in this field, only about 10 per cent ever gets into a pipe line or is used as fuel. The problem here is mostly one of proper government and control, so far as the community at large is concerned, and financial, so far as the transportation company is concerned.

As the gas in the Cushing field comes from the well, it is very far from pure or a perfect gas. It is composed largely of methane, with considerable quantities of the heavier hydrocarbons, ranging from ethane through the $C_nH_{2n+2}$ series, including those which at ordinary atmosphere conditions are vapors and are considered as part of the gas proper, down to heavy oils, and often salt water. The liquids are held in suspension as a fog or mist, or run along the bottom of the pipe and collect in low places. Between these extremes are all those compounds usually known as gasoline or flashy gasoline. Dirt, sand, etc., are also often present.

The first problem in the transportation of this gas was to separate dust and dirt, and such liquids as water, oil, or gasoline. For this purpose drips or separators were provided in the lines from the wells to the main trunk line. These drips vary widely in design, but are all intended to catch and store the water and oil until the patrol man can blow the line out to the atmosphere. The simplest drip is a Tee with the opening down, and one or two joints of pipe connected on as storage for the liquid that accumulates. This serves fairly well for any liquid not held in suspension in the gas, but, of course, does nothing towards removing the suspended liquid. A great many attempts have been made to remove this suspended liquid, usually by a separator working on the centrifugal principle; but it is a very

difficult matter, indeed, to remove the last traces of liquid in this way, and, so far, efforts in this direction have only been partially successful. A new type of drip has recently been developed in California, but it has not as yet been fully tried out.

Any liquid not taken out by the field drips tends to collect in low sections of the line, and drips should be provided at all these low points. If pockets of liquid occur in the line, they cause the flow of gas to be pulsating instead of steady. This pulsating is difficult to overcome entirely, and is one of the chief sources of trouble in the operation of measuring stations.

Gasoline and oil are the main cause of rapid deterioration in the joints in the pipe lines, which are usually packed by rubber or composition rings. The oil and gasoline attack the rubber rings quite actively, and sooner or later cause leaks and blow-outs, especially as the pressure carried in the line is from 200 to 400 lb. per sq. in. Several substitutes for rubber are being used and seem to be more resistant; but the only way to eliminate trouble from this cause is to keep gasoline and oil out of the line.

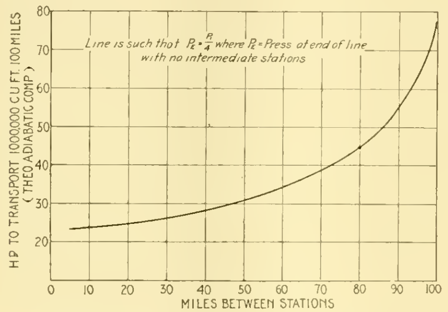


Fig. 1 Curve Indicating Relation of Distance Between Compressing Stations to Power Required

Gas entering the main trunk lines is often measured by orifice meters, and many points come up in connection with the practical use of these. In order to compute the amount of gas passing an orifice meter at any instant, it is necessary to know: *first,* the temperature of the gas; *second,* its gravity; *third,* the size and coefficient of orifice; *fourth,* the absolute pressure of the gas passing the orifice, and, *fifth,* the differential or drop of pressure in the gas in passing through the orifice.

The temperature is quite constant at any given time of year, and a mean temperature for the year is usually the contract basis on which gas passing a measuring station is computed and purchased.

The gravity of the gas is quite variable, even for gas coming from a given field; and when it is considered that gas passing a measuring station may come, in varying proportions, from several fields, the importance of making frequent determinations of the gravity of the gas passing a station to ensure accurate metering is evident. The gravity of gas varies in practice from 0.59 to 0.72, taking air as unity. It is determined by comparing the time for a given quantity of gas to flow through a small orifice with the time required for the same volume of air to pass the same orifice with the same head causing flow, and computing from the formula $G = \left(\frac{t_{gas}}{t_{air}}\right)^2$

So far as the writer is aware, nearly all gas companies, as well as companies manufacturing orifice meters, have been inclined to assume this gravity factor constant at 0.60 or 0.64. In all orifice meter measurements, as well as computations of line flow, or of Pitot tube measurements, corrections should be introduced for the gravity of the gas. In most of these computations the quantity will vary inversely as the square root of the gravity.

An idea of some of the problems incident to a compressing station may be obtained by a consideration of a typical compressing station of approximately 3000 h.p., which is capable of compressing about 40,000,000 cu. ft. of gas per 24 hours through 3 compressions and delivering it at 350 lb. gauge pressure. Up to this station the gas is transported by the natural field pressure. The prime function of the station is to re-compress the gas, which has dropped to a pressure too low for economical transportation, to a pressure high enough to deliver the requisite quantity through the remainder of the line to the points of consumption.

One of the chief problems is that of the condensation of gasoline in the line beyond the station. As the gas leaves the field, its pressure has been diminishing and its capacity for carrying gasoline as a vapor increasing. There is, therefore, little danger of deposit of gasoline in the line between the field and the compressing station. In this 40 miles of line practically all liquid has been removed by the drips along the line.

At the compressing station the pressure of the gas is raised to 300 lb. per sq. in. or higher, and its temperature raised to from 210 to 240 deg. fahr. After compression, the gas is passed through a cooler consisting of a large number of pipes in an open pond of water. Only occasionally is the temperature in the cooler low enough to condense out any great proportion of the vapors condensable at this pressure and line temperature. A separator is provided at the outlet of the cooler, but it can only take out vapors already condensed. It is, therefore, apparent that there is a possibility of further condensation of gasoline in the pipe line beyond the compressor station. This is exactly what occurs, and it causes a heavy depreciation in this part of the line. In one case, gasoline taken from a drip beyond this station was used in an automobile, and it was found that the exhaust smelled very strongly of burnt rubber. This would not ordinarily matter were it not for the fact that this same rubber has been dissolved out of the pipe joints, where it is very greatly needed.

From a theoretical standpoint it is entirely possible, by well-known processes, to condense and separate this gasoline before it enters the line. When it is considered, however, that there are 800 or 900 tons of gas passing this station per day, and that the gasoline content is very small, it is seen that the equipment necessary would involve a considerable investment, and the problem becomes a commercial one of whether or not the necessary equipment can be installed with an investment small enough to be profitable. This last problem will be special for each particular case, and is one which in most instances has not yet been solved.

Continuous accurate measuring of all gas into and out of the whole system is one of the perpetual problems of operation of any transportation company. In order to safeguard against loss due to the failure of any of the measuring apparatus, it is necessary to check up in all possible ways the quantities of gas passing meters. In some cases this can be done by line flow formulae, and in some by the displacement of compressing stations. It is found necessary and advisable to use both these methods wherever possible. The pipe line formula used is of the form $Q = K\sqrt{P_1^2 - P_2^2}$ where $Q$ is the quantity of gas, and $K$ is a constant depending on the length and diameter of the pipe line and the gravity and temperature of the gas. The formula for flow of gas through an orifice meter is of the form $Q = K^1\sqrt{hP}$ where $K^1$ is the constant of the orifice meter. In checking a meter by line flow formulae, the quantity involved is the same; therefore, by equating the two expressions and reducing, the expression $\left(\frac{K^1}{K}\right)^2 = \frac{P_1^2 - P_2^2}{hP}$ is derived. The ratio of the squares of the constants for any line and meter can be evaluated and is a constant. To check the meter against the line flow formula, it is then simply necessary to evaluate the expression $\frac{P_1^2 - P_2^2}{hP}$ and compare it with the constant derived as above. This check is so simple that meter station operators can easily make it and report the meter out of order, if the value figured is found greatly different from the constant.

It is well to point out here that if observed pressures are correct, the pipe line formula can never show an amount of gas passed less than the actual, but is apt to show a greater amount, due to excessive pressure drop from leakage or an obstruction in the line. The displacement of a compressor station gives a basis for comparison with the quantity of gas as shown by a measuring station which may show up defects in the operation of either. If the amount of gas measured would involve a volumetric efficiency of the compressors greater than 90 per cent, it is a very safe guess that the measuring station instruments are over-measuring the gas.

One very important function of a natural gas line is the equalization of the rate of production. The demand for gas in a city varies greatly from hour to hour of the day, being several times as great in the daytime as at night, and also varies greatly with atmospheric temperature. It would be a difficult matter to vary the output of a compressing station or a field at a distance from a town to meet the widely varying demand, if it were not for the equalizing effect of the transmission line. When the supply is greater than the demand, the gas is being stored in the line, and is available when the demand suddenly becomes much greater than the rate of supply. Often this equalizing effect will enable gas to be taken into the line at a uniform rate from the field for days at a time, while the demand at the other end of the line is fluctuating widely. The adjustment of supply to demand over the whole of a large system is an art in itself. It demands that all production shall be regulated from a central point by a dispatcher, who is in constant communication with all points of demand throughout the system.

Finally, regarding the problem of transporting gas by means of pipe lines and compressing stations, our gas fields are not only stores of latent energy in the form of fuel, but also stores of latent energy directly available as power in the highly compressed state of the gas. At present the pressure energy is used quite wastefully in the transportation of the gas itself. If, instead of allowing the pressure of the gas to drop to a third or a fourth of its initial value before re-compressing it, the pressure could be maintained at a high point, a great reduction in the total power required to transport the gas could be made. This would point to smaller compressing stations located at shorter intervals along the line. These stations would require less total power than stations at greater intervals performing the same service, and they could be simplified greatly by the omission of the after-cooler, as the smaller range of compression would not raise the temperature of the gas to an objectionable point. The curve, Fig. 1, shows the economy in power possible by more frequent stations operating through a smaller pressure range.

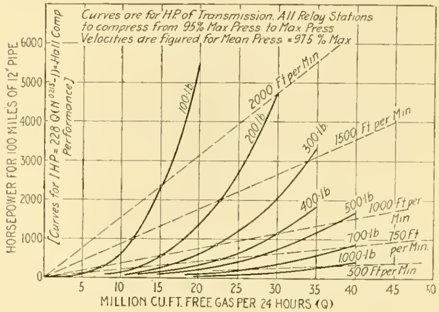


Fig. 2 Curves Showing Power Required for Transporting Gas at Different Pressures and Velocities

The curve in Fig. 2 has been prepared to show the relation between the amount of power required to transport different quantities of gas, the pressure at which the gas is transported and its linear velocity. In this case, the power is assumed to be applied at such frequent intervals along the line that the drop in pressure between the points of application of the power is only 5 per cent of the initial pressure. In other words, the pressure is maintained nearly constant, and the power applied represents the friction loss in the line at the pressure shown. It is seen that both the power required and the amount of gas vary directly with the linear velocity of the gas in the line. Also, that the power required to transport a given quantity of gas decreases very rapidly as the pressure at which it is transported increases, showing that there would be great economies possible if we could make our lines more perfect, so that higher pressures could be carried safely and without excessive leakage.

# METAL SPRAY PROCESSES IN ENGINEERING AND ART

BY JOHN CALDER, BOSTON, MASS.

Member of the Society

ONE of the great metallurgical problems of the day has been to produce a non-corrosive surface on iron and steel, the indispensable but vulnerable materials of engineering construction, without affecting the physical properties of these metals or the shape or usefulness of the object treated. This has been attempted by chemical, electro-chemical, and mechanical methods. Tinning, galvanizing and sherardizing are the ordinary wet and dry chemical methods of applying a protective metal coating directly to a considerable volume of engineered and manufactured product but these processes are narrowly limited in the variety of their applications. In the other chemical processes the iron and steel surfaces have been deliberately attacked by chemicals to form from them stable, adherent compounds as a protective overlay which preserves the remainder of the object from corrosion. This is the general method of what are known as the "rust-proofing" processes.

Plating, the electro-chemical method, furnishes a continuous thin metallic web around iron or steel objects submitted to it, provided the shape and size of the article are suitable. It is necessarily limited to small objects. The adhesion of the plated coating is slight and its continuity is essential for service. The tinned or galvanized coating adheres, due to chemical affinity for clean iron, but its irregularity gives much trouble. The dry zinc galvanizing, known as sherardizing, gives a better result but is limited to the application of one metal under heat conditions, which confine it largely to black work and to objects the distortion of which is of no consequence.

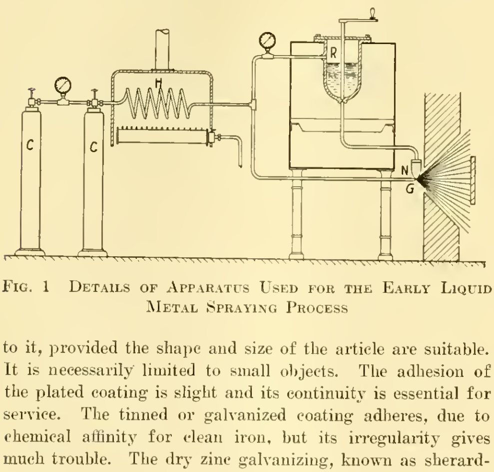


FIG. 1 DETAILS OF APPARATUS USED FOR THE EARLY LIQUID METAL SPRAYING PROCESS

None of the processes which have been briefly mentioned meet the general needs of the arts in a satisfactory way as they involve the exposure of engineered and manufactured products to injurious action from moisture, chemicals or heat. They admit of depositing only on metallic or metallized surfaces and they can apply but one or two metals out of the whole range of such elements and their alloys. They must ordinarily be applied to every part of the object and the deposits are not easy to control in the matter of location, quality and thickness. The permanence of the resulting adhesion is not assured and many of the coatings rapidly deteriorate.

There are demands in the arts for a method which will take the process to the work to be coated or to any part of it, and will secure the quick deposition on any coherent object, whether metallic or not, of any desired metal or alloy in any quantity, however minute. Inventors have labored over the problem for many years but commercial results have not been developed until recently because of the lack of economy in the earlier forms of apparatus, and even yet, the whole range of metals is not available. Effective pulverization of the very hardest metals still presents economic difficulties but lead, tin, zinc, aluminum, copper, nickel and their alloys can now be sprayed easily and these metals cover very well the practical range of protective coatings.

The overlaying of iron and steel for temporary effect with non-metallic substances such as paints, enamel, japan, and varnish has been the mechanical method necessarily followed hitherto for the great bulk of metal objects and structures and the renewal and maintenance of such protections involve enormous outlays. It is the object of this paper to describe the latest mechanical process, the Schoop process, for depositing electro-positive metals on iron and steel. Incidentally, the method permits the depositing of many other metals and alloys on coherent bodies whether metallic or not.

The process takes its name from M. U. Schoop, an engineer, of Zurich, who, in collaboration with other inventors, made the metal spray an effective coating agent. In the Schoop process, for which the United States patents have just been issued, the coating metal adheres to the object chiefly by mechanical union. The metal is discharged in hot impalpable particles moving with high velocity and these when directed upon a prepared object penetrate the pores of the latter while the spray is still plastic. The coating metal thus dovetails itself into the superficial pores of the object and does so in the presence of reducing gas which prevents oxidation at the junction of the metals.

The progress of invention on metal spraying has been chiefly directed toward making the metallic particles as small and as hot as possible, thereby avoiding oxidation, and reducing the pressure of air used and the cost of the gases employed. In 1902, Thurston was granted a patent (United States No. 706-701) for impacting, with unignited gas, metal in the form of dust upon a metallic base. His apparatus was not practical and no commercial results were obtained.

Within the past year, four United States patents have been issued which embrace all the important steps since Thurston's invention. Schoop invented (U. S. No. 1,128,058) a process for producing a fine spray from either molten or solid metal and also for producing separable metallic coat-

Presented at the New York local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on May 11, 1915.

ings or copies of the objects sprayed upon; this was known as the liquid metal spraying process. He later invented (U. S. No. 1,128,059) a process for projecting finely divided unmolten metal particles on to a surface, using an ignited gas and metal in the form of dust like Thurston; this was known as the metal dust spraying process.

Very soon afterwards Morf invented (U. S. No. 1,128,175) a process for melting, atomizing and projecting, practically simultaneously, solid metal and particularly metal in the form of wire; this was known as the metal wire spraying process. At the same time he also invented (U. S. No. 1,100,602) a successful apparatus (known as a "pistol") for effecting this process. These inventions above outlined form the basis

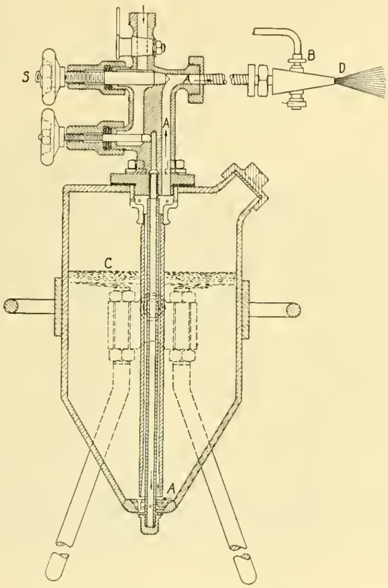


FIG. 2 PORTABLE APPARATUS FOR THE METAL DUST SPRAYING PROCESS

of the Schoop metal spray process as it is now operated in the United States.

The evolution of the apparatus has been interesting. The liquid metal process involved a large non-portable reservoir of hot metal weighing with the auxiliary parts over a ton; the metal dust apparatus weighed over a hundred pounds, while the "pistol" of today weighs less than four pounds. Figs. 1, 2 and 3 show the three forms through which the apparatus has passed.

In the apparatus represented by Fig. 1, a molten metal is allowed to run continuously from the reservoir *R* through a broad nozzle *N*, where it is broken up and swept away by a violent current of heated gas *G*, issuing under regulated pressure from containers *C* and reheated in its passage at *H*. The expansion of the gas chills the molten particles and forms a rapidly moving spray or fog of metal which impacts upon any object placed in its path and plates it.

Any metal fusible under the conditions of the apparatus can be used and owing to the low temperature of the fog, it is possible to plate very delicate and easily combustible objects, as well as metal articles. Aluminum plating, which could not be obtained by fusion or electrolysis on account of its ready oxidation, was easily obtained by this Schoop process.

The obvious objections to such an apparatus were lack of portability and the expense of melting and keeping fluid most of the metals in the unavoidable intervals of spraying. The result was that only the more fusible metals, lead and tin, were used where spraying on a continuous scale was possible and the liquid metal apparatus was never reduced to economical practice. It was observed with this apparatus, however, that the particles were not actually molten at the moment of impact and this suggested the next step.

Fig. 2 represents the second form of apparatus in which portability was secured and the metal particles to be sprayed were prepared in advance. Powdered metals in a very fine state of division have many of the characteristics of a liquid. Their fine particles mix with one another like drops,

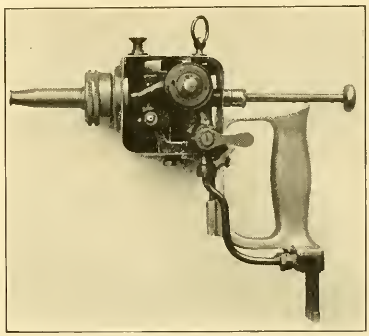

FIG. 3 EARLY FORM OF THE METAL SPRAYING "PISTOL"

they spread with facility and unite under the influence of very little force. The metal powder in the container *C* is entrained in an air blast *A*, heated in the flame of a blast pipe *B*, and projected with high velocity. The gas is burned at *D* and the supply of air is regulated at *S* to obtain complete combustion.

It was found that the anticipations from the use of the first apparatus were correct and that metal particles projected in a pasty condition produced plating as before. Most metal powders, however, tend to oxidize rapidly and the use of this apparatus was practically restricted to tin and zinc on this account. Even with tin, the expense of metallic powder was prohibitive, but the plating with tin and zinc was very good. In the case of zinc, the apparatus known as the cyclone is still the most economical instrument for plating large surfaces with that particular protective metal. Zinc dust is a by-product in the stacks of zinc smelteries. With the Cyclone apparatus, it can be impacted on steel structures either in the field or at the factory.

Inventors then set themselves to overcome both the chemical and economic difficulties, viz.: to dispense with mass melting and dust preparation and to secure instant and simultaneous operation of melting and pulverization, and control with a handy, economical and easily transportable

appliance. The result was the ingenious instrument known as the "pistol" which is shown in Fig. 3.

The principle involved consists, as shown in Fig. 4, in feeding a fine wire *W* of any metal into a reducing flame zone *Z* at such a constant speed that the position of the end of the wire *E* remains stationary, the melting rate being exactly equal to the rate of feed. Under such conditions the wire end melts a drop at a time and each drop at the instant of formation is struck a violent blow by an air blast *A*. In other words, the pistol is a machine gun which automatically manufactures its ammunition from a reel of wire and bombards the object to be plated with plastic projectiles of extremely small size.

The resulting fog or spray of fine metallic particles into which the drops are divided takes the form of a diverging cone *C* with a core of reducing gas *G* in which the particles are entrained, and a surrounding sheath of air *A* which is rapidly expanding and cooling. Any suitably prepared object placed in the path of this metallic spray is plated through impact without undue elevation of temperature.

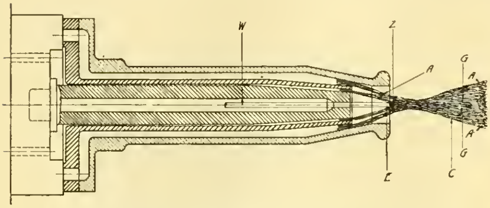


FIG. 4 DIAGRAM ILLUSTRATING APPLICATION OF REDUCING FLAME TO METAL WIRE IN THE PISTOL

Fig. 6 shows a section of the commercial spraying pistol now in use. The principal parts of the pistol consist of an outer casing *A*, cast of aluminum, with a central projecting tube forming a handle, a wire feed mechanism mounted entirely upon the cover *B* of the turbine chamber, the turbine *C* actuating the wire feed mechanism, gas, air and wire nozzles mounted upon the outer casing held in position by a hand nut *D*, and a removable cover *E* which completes the enclosure of the outer casing.

Gas and air ducts are drilled in the outer casing. The flow is controlled by the tapered valve *F* provided with a handle *G*. The wire feed mechanism is actuated by a turbine *C* mounted on a vertical shaft running in ball bearings; a worm is cut in the upper end of the vertical shaft and drives by worm wheels the horizontal shafts *N* and *O*, Fig. 6, which are provided with worms in turn driving the worm wheels *P* and *Q*.

The wheels *P* and *Q*, Fig. 6, are provided with slots to engage the projecting lugs of the lower feed wheel *R*. The upper feed wheel *S* mounted in the pivoted frame *T* is provided with shrouds controlling the position of the lower feed wheel *R*. The lower feed wheel can be engaged in either worm *P* or *Q* by raising a clip *I*, shifting laterally in either direction and locked in by the opposite clip. The shift can be readily made by allowing the mechanism to run slowly by a slight opening of the starting valve.

Pressure is applied to the feed wheels through the pivoted frame *T* by a coiled spring, and controlled by the operator by means of the release lever *K*. The final adjustment of the wire feed is controlled by the needle valve *M*, Fig. 6. The turbine and shaft complete is assembled in the outer case and properly adjusted independently of the other mechanism.

The wire feed is entirely assembled on the turbine cover *D* and, when properly adjusted, is secured in position. The wire nozzle base *U* provides an adjustment for position of wire and gas nozzles, and is secured in position by a headless set screw. The upper end of the stem of the turbine cover is provided with an annular groove, which is engaged by the spring loop *V* and secures the removable cover *E* of the case. Loop *V* provides also a means for hanging the pistol on a conveniently located hook.

The operation of the pistol is as follows: The gas and blast nozzle faces *B* and *C* are securely clamped to form gas tight joints by tightening the hand nut *D*. The end of the central or wire nozzle is then 0.015 in. inside the gas nozzle and the stationary melting point of the wire is 0.03 in. inside the air blast nozzle. The wire diameter used is from 0.0319 to 0.0375 in., except for lead and tin which are used in larger sizes owing to their rapidity of melting.

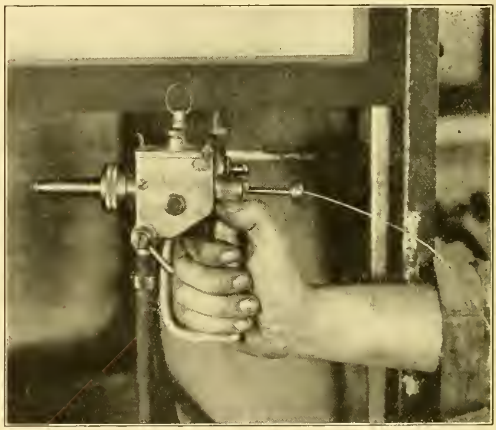

FIG. 5 VIEW OF A COMMERCIAL SPRAYING PISTOL IN HAND READY FOR USE

The feed gears having been set in mesh at the approximate speed required for the wire selected, the air alone is turned on and the speed tested with a short length of wire. Adjustment, if necessary, is made by the needle valve which modifies the speed 2 ft. per minute plus or minus.

The end of the wire reel is then threaded through the stock receiving tube, between the gripping feed rolls and into the central wire nozzle and the fuel gas pressures from the containers are adjusted by the reducing valves and gauges thereon to the tabular requirements for the metal to be sprayed. The pressures of the fuel gases seldom rise above one atmosphere and hydrogen or Blau gas are the reducing gases usually employed. This gas is now admitted by slightly opening the starting valve and when ignited with a match burns quietly as a pilot light.

The starting valve is then opened up full and oxygen is admitted gradually until the flame zone is established. All back-firing is avoided by keeping the reducing gas always in excess of the oxygen, the ratio being three or four to one. The above movements are made in rapid succession on a

light instrument which can be held in one hand and the spray is started up the moment the constant melting position of the wire is reached.

The spray so established is essentially a metal plating air-brush, the diameter of which 5 in. from the pistol end is about 2 in. Objects to be plated are operated upon by pointing the pistol normally to the surface to be coated at any moment at about 5 in. distance and traversing the pistol across the surface with a regular motion. A single coating is about 0.001 in. thick. The operator's vision easily guides him in distinguishing between the coated and uncoated portions and also between a first and second coat.

Two thousandths of an inch well impacted upon a surface are just as effective as a much greater thickness and of course unnecessary sprayed metal increases the cost, as the latter is directly proportional to the thickness. Not only on the score of economy but also to preserve toughness the coating should be of minimum thickness for the anvil action of the metallic spray on a solid metal object is lost above a few thousandths of an inch thickness and a process of cold working follows which produces a brittle scale readily detachable. In practice this matter is easily regulated.

Fig. 5 shows the pistol held in the hand ready for action with the wire thread in position. Fig. 7 shows the pistol applied to coat a wooden pattern for protection with lead, and in Fig. 8 a cement statuette is being covered with bronze.

Gas bombs with fittings and air at 40 lb. pressure are the only requisites besides the pistol and its hose connections for plating non-metallic objects such as wood, stone, paper, cement, cloth, etc. All metallic surfaces should have the scale cleaned off and their pores opened by preliminary sand-blasting.

It will be seen from Table 2 that 0.001 in. thickness, one square foot in area, can be sprayed with the common metals for a small sum. The total cost for German silver is $3\frac{1}{2}$ cents, for copper, 3 cents, for tin, 5 cents, for brass, $2\frac{3}{4}$ cents, for zinc, 2 cents, for aluminum, $1\frac{3}{4}$ cents and for lead $1\frac{1}{2}$ cents per square foot.

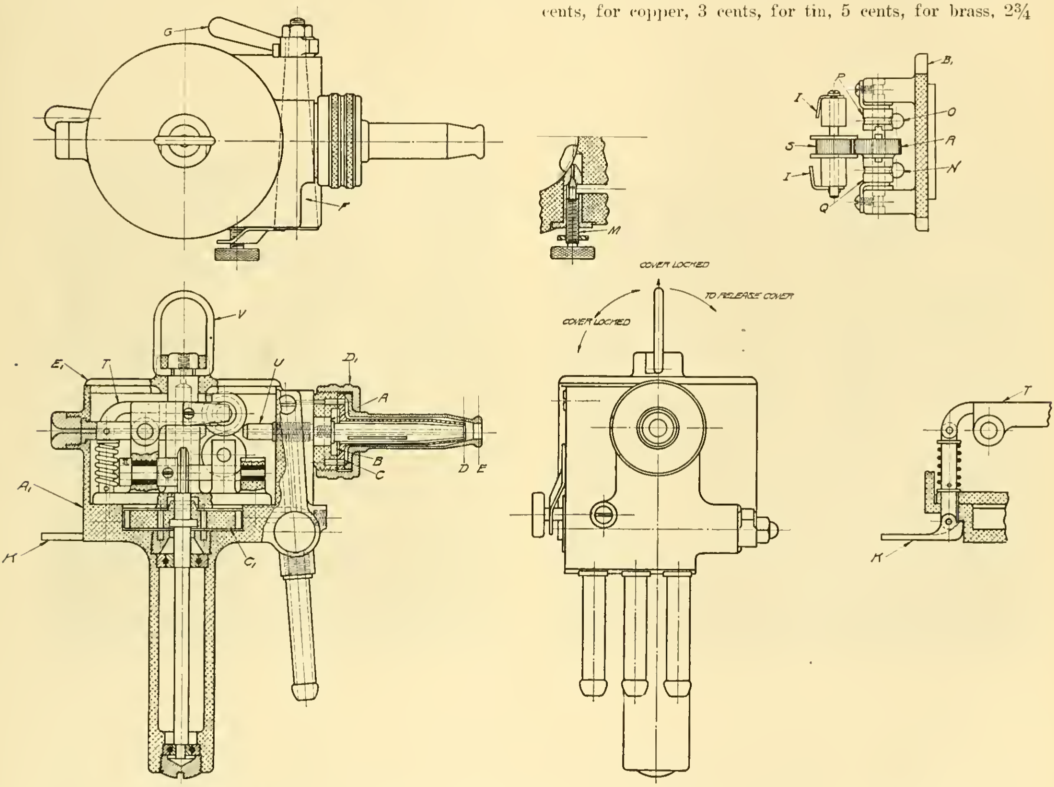


Fig. 6 Details of the Commercial Metal Spraying Pistol now in use, showing Turbine, Wire Feed Mechanism, Etc.

Various theories have been offered to account for the plating properties of the metal spray, but it is believed by those putting it to practical use that, except in the few cases where the impacted metals have a chemical affinity, the action of the spray is purely mechanical.

Any metal wire can be sprayed with varying degrees of fineness by the pistol, but a hard metal, such as copper, cannot be impacted with the same degree of adherence upon a solid copper object as it would be upon a more porous cast iron object or upon one of the soft metals such as lead or zinc. The coatings may be ground, polished and buffed like any ordinary metals, but polished sprayings do not offer

themselves as economical substitutes for cheaper and less adherent platings which are deposited in smooth condition.

As metal spraying is essentially a kinetic energy process the degree of adherence obtained in any instance depends upon the relative hardness and porosity of the sprayed metal and its base. For some decorative purposes this is of no consequence, but where stress, wear and chemical action are involved it is quite important to choose the appropriate coating.

In spraying where the softer metal forms the object, the body of it, as well as its superficial pores, will be penetrated by the harder metal with its projectile action. When the condition is reversed the softer spraying metal will fill the open pores of the harder object and key itself into the former in cooling off, but it will not penetrate the solid parts of the body. In either case, however, with proper preparation of clean open surfaces a durable adherent coating is obtainable.

Protective coatings on steel or iron may be either original coatings of the whole of an object or any part of it or local applications with the pistol to repair damage or wear of a coating made by another process. The repair of the troublesome defects on galvanized sheets is an example. The localization of copper deposits on iron aand steel for the purpose of the cementation process and for controlling hardening is easily and quickly accomplished by the pistol. The results are reported to be much better than those obtained from the necessarily irregular and soft electrolytic deposits, the area of which cannot be absolutely controlled.

Many engineering structures used in the arts, such as steel and iron tanks, girders and machinery of all descriptions, are subject to the action of liquids and chemicals and corrode rapidly, particularly at joints. It is not possible to plate such structures by any other coating method. In such cases a metal is selected which will resist the corroding agent and

Fig. 7 View of the Pistol as used for Coating Wooden Pattern with Lead

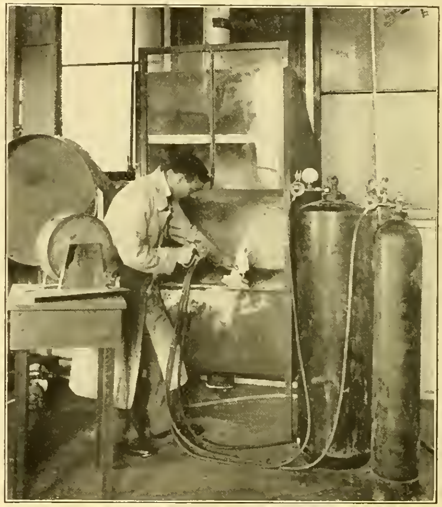

Fig. 8 Application of the Pistol in Coating a Cement Statuette with Bronze

The applications of the process already made are numerous and new ones are being suggested continuously. In this connection it should be noted that, though coatings of all the commercial metals and of their alloys can be made on any other metal, and on almost any coherent object, except articles containing grease, the choice of a metal coating should be conditioned by the service which it has to render.

Spraying a metal so that it plates an object gives the coating metal no chemical properties it did not possess before. Hence sprayed coatings used for protective purposes, rather than for finish or decoration, are restricted for resisting acids to lead, for resisting air, moisture, sea water, and ordinary atmospheric action to lead, tin, zinc and aluminum, and where superficial oxidation of the coating is of no importance copper and its various alloys can be freely used also.

In general the applications of the process may be divided in five groups, viz: protective coatings; bonding or junction coatings; electrical coatings; decorative coatings; detachable coatings. It is with the first three of these that the engineer is chiefly concerned.

is sprayed in the form of wire on all the seams and joints, these having previously been cleaned by sand-blasting.

In many cases the treatment of the joints is sufficient, the solid metal resisting oils and liquors for a long time when the seams are rendered free from attack. Railroad and bridge girders can be handled by portable outfits to protect them from the atmosphere and moisture. This is a large industrial field of application in which lead, tin, and zinc sprayings are used, and proper initial treatment of this kind or in the field during erection dispenses with all need for repeated painting.

Laundry machinery, dairy appliances, water heaters, and similar structures exposed to moisture and chemicals can be protected against corrosion due to electrolysis in many cases by sprayed deposits of zinc suitably located, or may be wholly tinned or galvanized by the Schoop process.

Bonding or junction coatings can be freely applied to brick, metal or porcelain connections with the metal spray. The porosity of stone, both natural and artificial, lends itself readily to this use. The refractory hearths of furnaces using

TABLE 1 DETAILS OF THE COST OF USING METAL SPRAYING PISTOL ONE HOUR

| METAL | Diameter, Inches | Speed of Wire in Feet per Min. | Pounds per Hour | OXYGEN | | | BLAU GAS | | | Labor per Hour | Cost of Air per Hour | Cost of Spraying | Wire Cost per Hour | Total Cost per Hour | Total Cost per Minute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Gauge Pressure | Cubic Feet | Cost at $.02 Cu. Ft. | Gauge Pressure | Cubic Feet | Cost at $.008 Cu. Ft. | | | | | | |
| Copper | .032 | 12 | 2.15 | 27 | 24 | $.48 | 25 | 13 | $.104 | .30 | $.20 | $1.08 | $.366 | $1.446 | $.0241 |
| Brass | .032 | 12 | 2.15 | 28 | 21 | .42 | 26 | 14 | .11 | .30 | .20 | 1.03 | .335 | 1.365 | .0228 |
| Bronze | .032 | 12 | 2.15 | 27 | 24 | .48 | 25 | 14.5 | .116 | .30 | .20 | 1.09 | .432 | 1.522 | .0253 |
| German Silver | .032 | 12 | 2 15 | 28 | 23 | .46 | 26 | 14 | .11 | .30 | .20 | 1.08 | .545 | 1.625 | .0271 |
| Aluminum | .0375 | 16 | 12 | 19 | 36 | .72 | 16 | 13 | .104 | .30 | .20 | .32 | .44 | .76 | .0127 |
| Zinc | .0375 | 18 | 4.3 | 15 | 20 | .40 | 13.5 | 10 | .08 | .30 | .20 | .98 | 1.23 | 2.21 | .0368 |
| Lead | .076 | 25 | 30 | 14 | 20 | .40 | 12 | 8 | .064 | .30 | .20 | .964 | 3 00 | 3.964 | .0661 |
| Tin | .061 | 25 | 15 | 13 | 24 | .48 | 14 | 10 | .08 | .30 | .20 | 1.06 | 10.50 | 11.56 | .1933 |

the surface combustion principle are readily bonded by the Schoop pistol to their porcelain or metal gas-conducting tubes by spraying the assembled parts with a metal of sufficiently high fusing point. Ordinary solders are of no service in furnaces depending upon radiant energy and the refractory cements and mortars will not stand the necessary stresses and wear.

This is a single instance of the possibilities in bonding non-metallic surfaces. Though the pistol coatings are amorphous and vitreous throughout and are not calculated to carry the stresses of ordinary metal parts there are many static uses of metal in which the Schoop coating is useful. The electric appliance field is one of these. Carbon in all its resistance forms can be freely sprayed with copper and that metal can be applied in minimum quantity to any piece or portion of a piece of apparatus.

The most recent electrical application is the construction of condensers, especially for wireless service. The Schoop pistol will spray an adherent coat of copper on ordinary sand-blasted window glass. Two-thousandths of an inch is sufficient to produce a highly efficient and cheap plate much superior to rolled tin foil coverings or galvanic deposits of copper on glass. Lead sprayed on glass also furnishes a very cheap and effective condenser plate.

The decorative coatings are of less interest to engineers, but the field is large and, apart from the coating of baser metals with the bronzes and other alloys, almost any metal can be sprayed freely on naturally porous substances such as wood, paper, cloth, stone, cement, etc., and sprayed coatings can either be polished, treated with chemicals to form various patina effects, or allowed to form a natural patina, thus securing protection of the material from atmospheric action.

The detachable coatings form an interesting study and have yet to be developed for many of the arts. In all the applications already described the object has been to obtain an *adherent* coating of any selected metal upon a clean sand-blasted metallic surface or upon a clean surface of a naturally porous non-metallic object.

It has been found that if the Schoop spray be turned upon a smooth greased surface of reasonable hardness, the bombarding fog of metal particles will remain upon the surface without impacting and will copy the surface to its finest line or detail. On cooling and tapping this reverse it detaches readily and by using it as a mold and repeating the treatment with a film of grease, a detachable copy of the original object, a coin, medal or any relief subject can be obtained in any desired metal.

The application of these detachable coatings to the printing plate, dental plate and other processes in the arts requiring rapid and accurate reproduction is now under development. It is obvious that copper and bronze of a crystalline hard character would give much greater service than the short-lived plates now used of soft electrolytic copper.

The various possibilities of the spray so far developed are indicated by the samples of its work exhibited and by the demonstrations of the pistol in actual operation. Tables 1 to 3 show the data of gas consumption and total cost of spraying a square foot 0.001 in. thick of some of the commoner metals by means of the Schoop pistol; also, the cost of spraying per pound and by the hour and the rate of deposition.

TABLE 2 COST TO COVER ONE SQUARE FOOT BY SPRAYING

| METAL | Diameter, Inches | Speed of Wire per Minute | Time to Cover One Square Foot | | Thickness, Inches | Cost of Spraying | Cost of Wire | Total Cost |
|---|---|---|---|---|---|---|---|---|
| | | | Min. | Sec. | | | | |
| Copper | .032 | 12 | 1 | 10 | .001 | $.021 | $.0076 | $.0286 |
| Brass | .032 | 12 | 1 | 10 | .001 | .020 | .0071 | .0271 |
| Bronze | .032 | 12 | 1 | 10 | .001 | .024 | .0101 | .0341. |
| German Silver | .032 | 12 | 1 | 10 | .0089 | .024 | .0105 | .0345 |
| Aluminum | .. | 16 | .. | 40 | .001 | .0128 | .0042 | .0170 |
| Zinc | .. | 18 | .. | 30 | .0015 | .0081 | .0115 | .0196 |
| Lead | .076 | 25 | .. | 25 | .002 | .0064 | .021 | .0274 |
| Tin | .062 | 25 | .. | 30 | .002 | .0088 | .0875 | .0963 |

TABLE 3 COST OF SPRAYING ONE POUND

| METAL | Feet per Pound | Speed of Wire in Feet per Min. | Time to Spray One Lb. | Cost of Spraying | Cost of Wire | Total Cost |
|---|---|---|---|---|---|---|
| | | | Min. | | | |
| Copper | 340 | 12 | 28 | $.50 | $.1725 | $.6725 |
| Brass | 350 | 12 | 28 | .47 | .1625 | .6325 |
| Bronze | 344 | 12 | 28 | .53 | .2225 | .7525 |
| German Silver | 330 | 12 | 28 | .51 | .25 | .76 |
| Aluminum | 761 | 16 | 48 | 1.075 | .37 | 1.445 |
| Zinc | 283 | 18 | 14 | 2 27 | .33 | 2.60 |
| Lead | 50 | 25 | 2 | .032 | .10 | 132 |
| Tin | 105 | 25 | 4 | 07 | .70 | .77 |

# THE ELECTRIC LOCOMOTIVE

BY A. H. ARMSTRONG,[1] SCHENECTADY, N. Y.

Non-Member

*THE meeting of the local section of the Society in Chicago held on May 14, 1915, was devoted to the subject of The Electric Locomotive as applied to steam railroad conditions. Addresses were presented by A. F. Batchelder and A. H. Armstrong of the General Electric Company, Schenectady, N. Y., the first speaker discussing the development of heavy electric traction from the historical Baltimore & Ohio tunnel locomotives installed in 1895 to the most recent applications in the Butte, Anaconda & Pacific and the Chicago, Milwaukee & St. Paul electrifications; Mr. Batchelder's remarks were in the nature of an informal talk illustrated by numerous lantern slides. Mr. Armstrong supplemented the first speaker's descriptive talk with interesting comparisons with the steam locomotive as to the selection and rating and his remarks are presented herewith.*

The first 47 New York Central locomotives of the S type represent a distinctive type admirably adapted to high speed passenger service. This type is designed to deliver a moderate tractive effort at a high speed, giving a tractive effort of 7,100 lb. continuously at a speed of 56 miles per hour and a one hour rating of 20,600 lb. The driving motors, four in number, are thus able to give an output of 2,200 h.p. for a period of one hour without overheating. The later T type of locomotive, weighing approximately 130 tons, has a capacity of 14,000 lb. tractive effort at a speed of 53½ miles per hour or a continuous capacity of approximately 2,000 h.p. output of the motors. For the one hour period, the output is 2,600 h.p.

The reference to continuous and one hour capacities and also to starting tractive effort may demand the explanation to the steam railroad man that the time element plays a very important part in the determination of the rating of an electric motor. In a steam locomotive, the tractive effort or pulling power is determined by the diameter of the piston and the steam pressure behind it, and the locomotive can deliver this tractive effort continuously provided it has sufficient boiler capacity to supply the quantity of steam demanded and the fireman is sufficiently industrious to keep covered the grate which is supposed to have sufficient surface. With the electric locomotive on the contrary, allowance must be made for the fact that the insulation used deteriorates if heated continuously above a certain amount. It takes a considerable time for the motor to heat up to this dangerous point, thus giving rise to a momentary rating or starting effort, a one hour rating and a continuous rating, the latter being the output which the motors can give continuously without injurious heating. In other words, the steam locomotive engineer is concerned in keeping his boiler hot, while the effort of the designer of electric locomotives is to keep his machine cool.

In the early electric locomotive design there was no such thing as continuous rating. The service which it was called upon to perform was of an intermittent character, the runs between stops were short and the designing engineers were concerned mostly with the question of starting or accelerating, tractive effort and commutation. Therefore, the continuous rating of the early motors had no place in considering its design. With the extension of electrified lines and more especially with the introduction of the electric locomotive on main steam trunk lines, it was found that the motive power was called upon to deliver a continuous output for long periods at a time, and it became necessary to introduce air-blown or ventilated motors as well as fire proof insulation in order to secure the large output required without exceeding the limitations of space and weight imposed by standard gauge and reasonable diameter of wheels, wheel base and weight per driving wheel. We are therefore designing electric locomotives to-day suitable for the heaviest class of freight and passenger service. Such locomotives are entering into competition with the steam locomotive with a full appreciation of the phenomenal growth and possibilities of the latter as developed during the past few years, as well as a knowledge of the growth in the demands placed upon the motive power to take care of modern high speed passenger and freight train service.

In designing such electric locomotives, the electrical engineer is fully alive to the fact that a steam locomotive has been built weighing 750,000 lb. on drivers and having a total weight of 850,000 lb., and that nearly 90 per cent of the total weight of locomotive and tender is now rendered available for tractive purposes by the development of the Mallet principle to include cylinders placed upon the tender itself. It is also known that the tractive effort of these locomotives has increased from the 40,000 lb., of the early consolidation engines weighing 200,000 lb. on the drivers, to values as high as 160,000 lb. for the latest type of Mallet. It is also known that the introduction of the steel passenger car, together with the need of high sustained speeds of between 60 and 70 miles per hour, call for the hauling of passenger trains weighing over 1,000 tons and provision is made in the latest New York Central electric locomotive to take care of 1,200 tons at 60 miles an hour. Due appreciation is also paid to the results secured with the combination of superheating and simple engine which has so largely replaced the compound. Also the increased capacity afforded with the use of mechanical pushers and fire door openings with hand firing has increased the efficiency of the fireman so that it is now possible for him to throw between 5,000 and 6,000 lb. of coal per hour where previously 4,000 lb. might be considered good performance. Finally it is fully understood that the modern steam locomotive has been so improved as to fuel economy by the introduction of superheating, fire arch and other developments that it is possible to get an indicated horse-power with the expenditure of 15 lb. of steam and less than 2 lb. of coal under the best conditions of operation, and that with the use of mechanical stokers or with oil fired boilers, locomotives are in operation giving 3,000 i.h.p. or more.

Fully appreciating the above facts and the magnitude of

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Account of meeting of the Chicago local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on May 14, 1915.

the problem confronting him, the electric railway engineer nevertheless offers in the modern electric locomotive a type of motive power which can accomplish results in transportation which are not possible to obtain with the steam locomotive both as regards tonnage handled, speed on mountain grades and general flexibility and economy in operation. The first large electric locomotive built was placed in operation on the Baltimore & Ohio Railroad in 1895, and it is worthy of note that this was a gearless locomotive and a forerunner of the highly efficient gearless locomotives now in operation upon the New York Central Railroad to-day. The New York Central locomotive, as developed in the later T type, is capable of hauling the heaviest overland passenger trains over any length of track that may be electrically equipped, and with-all at a cost for upkeep, including all labor and material spent in maintenance, of not exceeding 3½ cents per mile run, as is shown by the records of the New York Central during the operation of the past seven years.

The first railroad in this country to adopt electric freight locomotives having large sustained output capacity was the Butte, Anaconda & Pacific Railway. Some three years ago the construction of 92 miles of the total of 114 miles of track was commenced, being completed for freight operation in May, 1913, and for complete freight and passenger operation in October, 1913. There are still four or five steam engines in operation on Butte Hill, but these will be replaced in the near future, so that in a short time the entire road, or 114 miles of track, will be in operation electrically. The one motive inspiring this installation was economy in operation, and preliminary reports indicated that the savings in electric over steam operation should be sufficient to pay something like 17½ per cent upon the capital required to electrify. During the first six months operation of this road, careful detail figures were kept on the cost of electric operation, every item of expense being accounted for, with the result that, prorated over the entire fiscal year, there was a saving shown of $240,000 over the cost of steam operation during the previous year with practically the same tonnage handled. The entire first cost of this installation, including all material and labor and contingent expenses as well as interest on money during construction, was approximately $1,200,000, so that the saving above indicated results in a 20 per cent gross return upon the capital required for electrification. This makes no allowance for the scrap value of more than 20 steam locomotives discarded.

On this road, the heaviest class of freight trains are operated electrically, regular operation calling for the movement of from 3,500 to 4,000 tons behind the locomotives from the Butte Yards to Anaconda, and record has been made of train weights as high as 4,500 tons trailing against a gradient of 0.3 per cent. Each locomotive (Fig. 1) weighs 80 tons, all on drivers, and two such units are coupled together, operated by one engineer and comprise a complete locomotive hauling the above tonnage. At the Butte end, there is a gradient of 2½ per cent against the returning empty cars, and at Anaconda 1.1 per cent grade against which one of the above locomotives hauls 25 cars or approximately 2,000 tons.

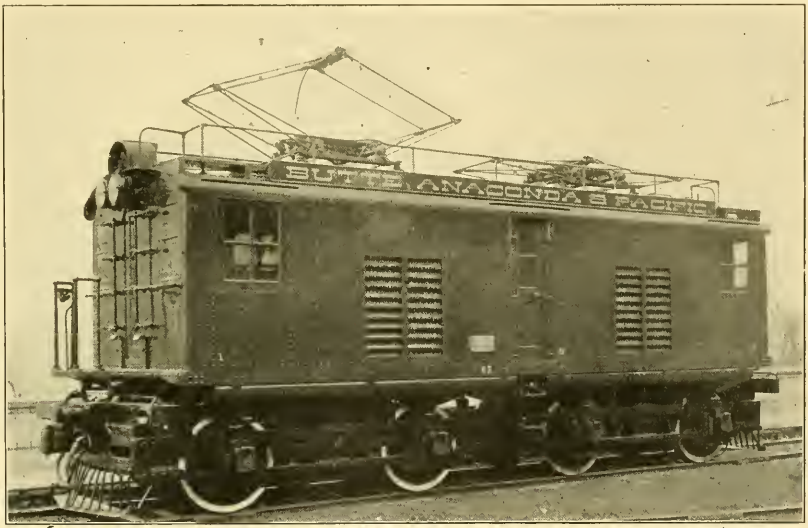


Fig. 1 The 80-Ton Locomotive Unit of the Butte, Anaconda & Pacific Railway

This leads up to the subject of the rating of an electric locomotive. The Butte locomotive (Fig. 1), weighing 80 tons, all on drivers, will give a continuous tractive effort of 26,000 lb. at a speed of approximately 16½ miles per hour at full substation line voltage; this corresponds to 16¼ per cent of the weight upon the drivers. Investigation of the locomotive loading regulations on many steam roads operating over ruling grades indicates that it is almost universal practice to assign to a locomotive a trailing load so that the tractive effort at the rim of the drivers, as required on ruling grade, will be equivalent to approximately 18 to 19 per cent of the weight upon the drivers. In other words, from 18 to 19 per cent coefficient of adhesion between driver and rail is now considered good steam practice, and the electric locomotive

rating is closely following this same steam practice. The electric motor, of course, gives a perfectly uniform rotation to the driving wheels, and should thus give something like 10 per cent more tractive effort than the steam locomotive with its reciprocating parts. Continued operation will develop whether this additional 10 per cent tractive effort can be utilized or not. In the meantime, steam practice is being followed in the loading of electric locomotives.

In adopting a coefficient of adhesion of 18 or 19 per cent as the basis of determining the tractive effort required on ruling grades, it is evident that there is left for starting purposes the difference between the above coefficient of adhesion and the slipping point of the wheels, whatever that may be, as determined by the condition of the track. Tests on electric locomotives have shown a coefficient of adhesion as high as 35 per cent, or even more under specially favorable conditions, but it is fair to assume a maximum of 30 per cent as available in operation and even 25 per cent may be nearer the average. There is therefore, not much difference between the tractive effort required on ruling grades and that required for starting, and in order to be "fool proof" and capable of meeting the exacting demands of the heaviest kind of service, the electric locomotive should be capable of delivering continuously a tractive effort equal to from 16 to 18 per cent coefficient of adhesion of the weight upon its drivers. The Butte locomotive is therefore rated at 26,000 lb. or 16.25 coefficient of adhesion as its continuous output, and this capacity is sufficient to meet all demands of operation on the Butte, Anaconda & Pacific Railway.

Coming now to the latest type of trunk line electric locomotive, the one designed by the General Electric Company for the Chicago, Milwaukee & St. Paul Railway (Fig. 2) is direct development of the Butte, Anaconda & Pacific both as to type of locomotive and general system of electrification installed. The weight of the locomotive is 260 tons, of which 400,000 lb. are on the drivers. Each of the eight driving motors has a continuous rating of approximately 375 h.p., making the sustained continuous output of the complete locomotive, 3,000 h.p. at the rim of the drivers. This locomotive, however, will give a considerably larger output for short periods. For example, it has a capacity of 3,440 h.p. for one hour and even greater than this for short periods. The sustained tractive effort is 72,000 lb. at a speed of 15¾ miles per hour at full substation line potential.

Compare this electric locomotive with the Mallet engine of approximately the same weight now in operation on the St. Paul road, as shown in Fig. 3, and we find that the Mallet engine has 76,200 lb. tractive effort corresponding to 23.5 per cent coefficient of adhesion, but those of you familiar with the performance of this particular engine know that it toils painfully at speeds seldom exceeding 7 to 10 miles per hour when operating at its full hauling capacity. It is in this matter of higher speed for the same tractive power that the electric locomotive excels. In fact the question of speed is simply one of cost and expediency, as the horse-power output of the electric locomotive can be raised to any value desired without exceeding the limits of track loading.

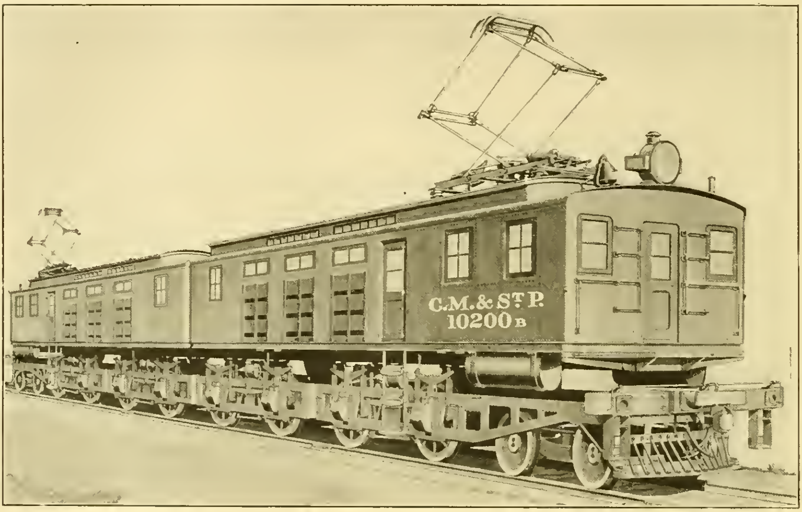

Fig. 2 The Double Unit 260-Ton Locomotive of the Chicago, Milwaukee & St. Paul Ry.

The St. Paul locomotive, weighing 260 tons, has capacity to haul a 2,500 ton trailing load behind the locomotive on a 1.0 per cent grade at nearly 16 miles per hour without any assisting locomotive. The St. Paul road in Montana and Idaho crosses three mountain ranges, the Belt Mountains, the Rocky Mountains and the Bitter Root Mountains. From Lombard to Summit, in the Belt Mountains, a distance of 49 miles, there is an average gradient of 0.71 per cent and a ruling grade of 1 per cent against which one locomotive will haul a trailing load of 2,500 tons without assistance. Between Pidemont and Donald, a distance of 22 miles to the summit of the Rocky Mountains, there exists a 2 per cent grade against which two locomotives will haul 2,500 tons trailing, the second locomotive being used at the rear of the train as a pusher. A second pusher division exists in crossing the Bitter Root Mountains of Idaho, making only two

pusher divisions in the 440 miles of electrified road from Avery, Idaho, to Harlowton, Montana.

The general design of the St. Paul locomotive, as shown in Fig. 3, comprises a locomotive divided in halves for facility in shop repairs, each half being identical and equipped with four driving axles and two guiding axles. The design is identical with the Butte locomotive except for the addition of the four-wheel guiding truck at each end of the locomotive. One of the reasons for the introduction of the truck is that the same locomotive is thus made available for both passenger and freight service. This does not mean that any locomotive can be used interchangeably at will in both freight and passenger service, but it does mean that all parts of the locomotive are identical whether used for freight or passenger with the single exception of the gearing between motors and driving axles which has a ratio of 4.56 for freight service and 2.45 for passenger service. This adoption of a uniform type of motive power for all classes of service should result in affecting a great reduction in the cost of maintaining the locomotives of the four engine divisions electrified.

A second type of light locomotive for shifting service may be introduced later, although in this connection arrangements are being made to operate independently one-half of the through locomotive by equipping it with draft gear in place of the articulated joint joining the two halves. This will provide a locomotive weighing 130 tons having 200,000 lb. on the drivers and capable of doing one-half the work stated above as the capacity of the combined locomotive, this half locomotive requiring turning if used in passenger service, as it has guiding axles at one end only.

The installation on the St. Paul road will use for the first time on such a large scale a principle which should be of the greatest advantage in the operation of mountain grade divisions, that is, the utilization of the motors on the locomotives to brake the train on down grade and return the energy of the descending train back into the line. The efficiency of the locomotive, both electrical and mechanical, is nearly 90 per cent maximum, not taking into account the minor losses in driving ventilating fans and air compressors. When descending heavy grades, therefore, the reversible feature of the locomotive, permitting it to transform mechanical power received into electrical energy, suggests by this means a considerable reduction in the amount of power required to operate the road. It is probable, however, that a power saving of less than 10 per cent will result from the regenerative braking feature of the electric locomotives, and the principal advantage resulting from the introduction of the electric brakes will be to relieve brake shoes and wheels from the dangers attending overheating. To those of you who are familiar with the handling of trains on long and heavy down grades this argument will appeal in full force, as it is not an uncommon sight to see brake shoes red hot as a result of sustained application on down grades of long extent.

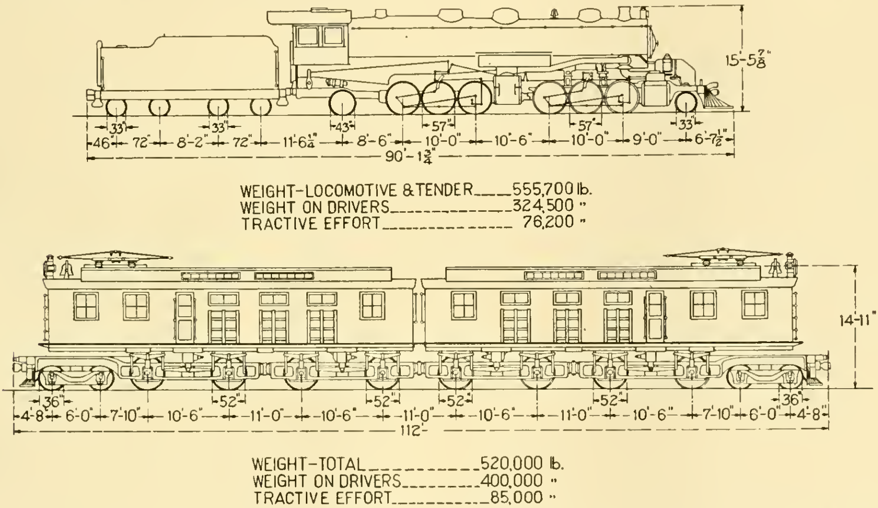


Fig. 3 Comparative Data on the St. Paul Mallet Steam and Double Unit Electric Locomotives

In regard to the suitability of the New York Central gearless type of locomotive for passenger service, it has been pointed out the entire absence of mechanical losses in the motor other than the brush friction on the commutator, but the facts are so important as to bear repetition. There are no bearings on the motor of any kind as the armature is mounted directly upon the driving axle and the field structure is part of the frame which is carried upon the journals. The electrical efficiency of the motor and the frictional losses on the commutator due to the brushes are therefore the only losses to be considered, and the efficiency of this locomotive in operation is therefore between 93 and 94 per cent. In other words, of the electrical input received at the third rail shoes, from 93 to 94 per cent appears as useful mechanical output at the rim of the drivers. This in itself is a most remarkable performance, but the value of this high efficiency locomotive is rendered more important when it is explained that the maximum efficiency occurs at approximately the free running speed between 50 and 60

miles per hour. In other words, the motor has a drooping efficiency curve, being highest at free running and lowest at overloads or during acceleration, and in this respect being just the reverse of the efficiency curve of geared motors which reach their highest point at practically the one hour load capacity of the motors. The gearless locomotive is therefore particularly adapted to operate on fairly level profiles and could not be utilized to such great advantage on roads like the St. Paul which contains many heavy grades sustained over long extent. It is very difficult to combine in one structure motors capable of hauling 800 tons trailing over heavy sustained grades, and also have the chaaracteristics required for good operation on level track at 60 miles per hour, and in the St. Paul locomotives recourse to gearing between motor and driving axle appears necessary to secure the greatest all around advantages at the lowest first cost.

In answer to the questions asked, it may be said that the control used is an adaptation of the multiple unit control in use on the elevated systems. It permits the operation of the double locomotive from one master controller located in the operating cab of the leading half locomotive; it also permits running two locomotives together and still under the control of one operator. It is a question, however, whether the strength of the draft rigging will ever permit coupling two of these large electric locomotives together at the head end of the train, in as much as the starting effort of one locomotive is 120,000 lb. and the 240,000 lb. starting effort of two locomotives would undoubtedly prove too much for any draft rigging now in use.

The trolley construction used upon the Butte, Anaconda & Pacific Railway comprises a steel catenary from which is hung, by means of loop hangers, a 4/0 copper trolley wire operating at 2,400 volts direct current. The loop hanger permits this trolley wire to ride up and down under pressure of the current collector and independently of its catenary support, and this provides a very flexible form of construction. The result has been that the 5 in. steel tube rollers used to collect the current on the Butte, Anaconda & Pacific have given a life of nearly 30,000 miles when operating in passenger service where the maximum speed approaches 50 miles per hour. The construction being installed upon the Chicago, Milwaukee & St. Paul Railway, is a development of that now in successful operation upon the Butte, Anaconda & Pacific Railway. It utilizes the 4/0 steel catenary and the loop hanger, but provides for two 4/0 trolley wires located side by side and alternately suspended from the same steel catenary. This alternate suspension of the twin trolley conductors provides for extreme flexibility of the overhead conductor, as when the current collector passes beneath the clip of one strap hanger the other trolley wire is hanging free and there is absolutely no tendency to spark, as is the case with the single conductor. Tests made at the Schenectady and Erie Works of the General Electric Company show that 2,000 amperes can be successfully collected at 60 miles per hour and as this corresponds to 6,000 kw. at 3,000 volts, it is considerably in excess of the requirements of one locomotive collector.

The statement can be safely made therefore, that the high-voltage direct-current locomotive can be designed to meet the requirements of the heaviest class of main line service both as regards the capacity of its motors and ability to collect the required amount of current from the overhead trolley wires at any speed called for in passenger or freight service.

# LOCOMOTIVE SUPERHEATERS

BY R. M. OSTERMANN, CHICAGO

Member of the Society

THE influence of superheating upon the design and operation of railroad locomotives is quite revolutionary, and much more unusual than upon stationary power plants. The keynote of locomotive design and operation has always been simplicity, and railroad men have maintained an attitude of conservatism well founded upon their experience in operating numerous individual power plants with a high degree of precision and often under conditions adverse to the proper maintenance of any kind of machinery. However, that there are to-day in operation about 32,000 locomotives equipped with just one design of superheater, nearly 12,000 of which are being used on the railroads of this continent, and that a very large percentage of the locomotives being ordered at this time are to be equipped with the device, is a proof that the benefits of superheating are appreciated.

In locomotives, the particular value of an improvement in cylinder performance, or, in other words, of a reduction of weight of steam used per indicated horse power hour, is to be found in the limitations of weight and clearance imposed upon the boiler, limitations which have been felt more and more as the demand for horse power capacity increased.

In proportioning his engines and boilers so as to furnish a given amount of sustained power, the stationary plant designer has no serious difficulties if he can obtain sufficient boiler room space and substantial foundations. His problem resolves itself into choosing, among the known improvements, a combination that will produce the required horse power with a minimum of coal and a maximum assurance of uninterrupted service.

The problem of the locomotive engineer is fundamentally different. He must obtain a certain sustained power from a boiler limited in weight to what is required for adhesion and in bulk by what road clearance and track curves allow.

The desire to increase the operating efficiency of existing track, the inability of the railroads to reduce grades in pace with the development of the traffic in many cases and the recent introduction of all-steel and steel underframe cars, are factors that are responsible for the rapid growth of weight and power of locomotives in this country. The average weight has been increasing rapidly. The boiler barrels of locomotives have reached their practical limit in diameter, and their length has also greatly increased with the increase in the number of driving axles to safely take care of the larger adhesion weights corresponding to the increased cylinder power.

A comparison of heating surfaces in stationary and locomotive boilers is very instructive. While in stationary boilers a square foot of heating surface is provided for evaporating from 4 to 7 lb. of water per hour, locomotive boilers have to evaporate as much as 20 lb. or more per sq. ft. of heating surface. Some recent Pennsylvania tests indicated evaporations of 23.3 lb. per sq. ft. of heating surface under forced conditions and with coal fuel.

In view of such extraordinary figures, illustrating better than any arguments could the limitations of steam generating

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in locomotive operation, any device that would reduce the pounds of steam per indicated horse power hour and at the same time could be applied without materially impairing the boiler efficiency or greatly increasing the weight of the locomotive, two important considerations, would afford material relief; and a correctly designed locomotive superheater is such a device.

The prevailing type of locomotive superheater is shown in Fig. 1 and a unit in detail in Fig. 2. More than 11,000 superheaters of this design are now in use in this country. This superheater is of the firetube or, more generally speaking, of the parallel-flow type, in distinction to the smokebox superheater which operates on the series principle or, in other words, utilizes the heat of the gases left after their contact with the evaporating surface.

Fig. 3 is a curve showing a general relation between coal consumption per indicated horse power hour and superheat, as experimentally established by Dr. W. F. M. Goss, to whom we are greatly indebted for a thorough investigation of the subject of superheating carried out on a locomotive at the Purdue testing plant. The curve is interesting in so far as it clearly shows the larger proportionate economies with increase in steam temperature.

The Pennsylvania Railroad has also carried out extensive tests at its Altoona testing plant, and the bulletins issued by this company giving the results of these tests are recommended to all who wish to make a detailed study of locomotive fire-tube superheaters. The tests fully confirm the claims made by the designers of this type of superheater, and show the following fundamental relations:

The superheat increases at a nearly constant rate with the indicated horse power of the locomotive. It also varies in a generally similar manner with the draft and the rate of evaporation, both of which are automatically regulated to suit the load of the locomotive through the agency of its exhaust. The superheater is, therefore, an effective power booster for the locomotive, and this is a very valuable feature from an operating standpoint. An increase in the steam demand upon the boiler necessitates the evaporation of more water per square foot of evaporating surface, which latter results in a more intense action of the superheater in decreasing the specific steam consumption of the locomotive.

The saturated steam locomotive boiler does not possess any boosting feature. On the contrary, the moisture in the steam fast increases, making the saturated locomotive fail when forced.

The benefit of the superheater in boosting the steam temperature and power of the locomotive probably finds its limit at the point where too great an increase of cut-off halts a further reduction of specific steam consumption. Just at what speed and power this takes place depends upon the proportions of the boiler, as compared with the cylinders and wheels; and the problem of the designer is to provide a boiler with proper proportions of evaporating and superheater heating surface so that the largest possible amount of sustained horse power can be had at the speed at which the engine is required to operate normally.

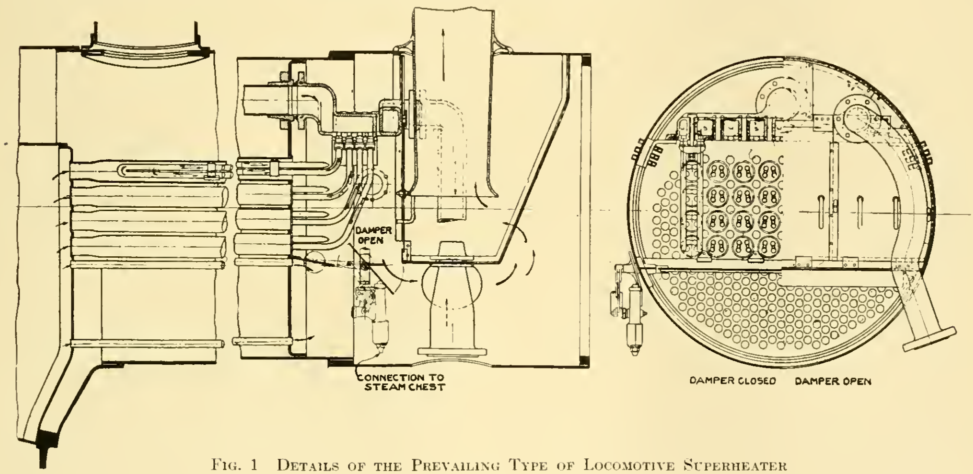



Fig. 1 Details of the Prevailing Type of Locomotive Superheater

A comparison of indicator cards taken from saturated steam and equally-sized superheated steam locomotives for either equal power output or equal steam consumption or water rate is most impressive. This comparison can be found in the above-mentioned Pennsylvania reports. In a locomotive, the area of the indicator card is indicative of haulage capacity. The greater the area of the card at a certain speed, the more tons can be hung on the drawbar, and the greater the earning capacity of the locomotive. The addition of a correctly-designed superheater makes it possible to increase greatly the area of the card at a certain speed, and therefore to increase the haulage and earning capacity beyond that of a saturated steam locomotive by increasing the cut-off or by "dropping her down," and still retain the balance between steam generation and consumption.

Savings in coal and water per unit of power developed, such as shown by the tests, are now being obtained in everyday operation. As a rough average, a coal saving of 25 per cent and a corresponding water saving of 35 per cent, while the engine is performing useful work, can be expected, and thermally accounted for, with the knowledge we have of the average amount of cylinder condensation which takes place in saturated steam locomotives.

Comparing two locomotives with identically the same engine and wheels—a case which presents itself often when a superheater is applied to an existing saturated steam locomotive—and assuming further that it would be possible to take sufficient horse power out of the superheater engine so that it burns the same quantity of coal per hour as the saturated engine without an appreciable increase of coal consumption per indicated horse power developed, then on the basis of the fact that the superheater engine can produce one horse power hour at 25 per cent less coal than the saturated engine, we can inversely figure that the superheater engine has 33⅓ per cent more cylinder horse power and from 45 to 55 per cent more drawbar horse power available than the saturated engine.

In operating terms, drawbar horse power is tractive power times speed of train. For the same speed of both engines and trains under comparison, the drawbar pull is about proportional to the tonnage, so it would seem that the superheater engine can haul 45 to 55 per cent more tonnage at the speed of the saturated locomotive working at a correspondingly larger cut-off than the latter. That is, however, practically impossible for the following reasons. The superheater locomotive has no more starting effort than the saturated locomotive of the same engine dimensions; particularly on poorly graded roads, the starting feature governs the tonnage which can be handled. Besides, the specific coal consumption naturally increases as the cut-off is increased, on account of decreasing cylinder efficiency; and how much this factor does towards preventing too great an increase of tonnage depends upon the cut-off at which the saturated engine had to be worked, whether over or underboilered.

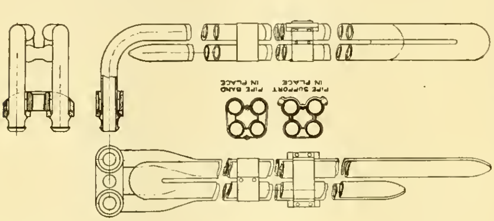


Fig. 2 Details of the Unit of the Locomotive Superheater

An increase of speed is often possible in practice in order to utilize the greater drawbar horse power available. In that case, the drawbar pull increases also per ton of train handled; but all the excess of drawbar horse power as potentially existing can hardly ever be utilized in practice. Therefore, part of the benefits of superheating must always be reaped in the form of saving in fuel and water and in the physical efforts of the fireman.

It is as much as stated above that the proportions of the superheater within the given locomotive boiler determine the curve of sustained horse power available at various speeds. These proportions are actually characterized by the ratio of resistances to the flow of the two parallel streams of gases, the one flowing through the large flues in contact with the superheating and the evaporating surfaces, and the other in contact with the evaporating surface only. For a given length of boiler this ratio is dependent upon the ratio of net internal area through the large tubes and through the small smoke tubes; and upon it depend the steam temperatures obtained in the cylinders at various power outputs, which is the power boosting and economizing feature of the firetube superheater.

At the present time, locomotive superheaters are so designed that temperatures of about 620 to 650 deg. Fahr. are obtained for maximum sustained horse power. The steam temperature is of incidental interest only; and it is not the purpose of the design to reach a certain temperature. What is required is a maximum increase of sustained power from a given locomotive. The more superheater units are applied, the more highly can the steam be superheated; but also the greater is the sacrifice of evaporating surface, and, in consequence, the misgivings of the designer of olden days. The intrusion of the superheater units into the boiler meant a compromise; but the influence of superheating upon specific steam consumption is so great that the net result is a tremendous gain.

Fig. 4 suggests that still greater fuel economies and power increases than at present obtained can be had from the

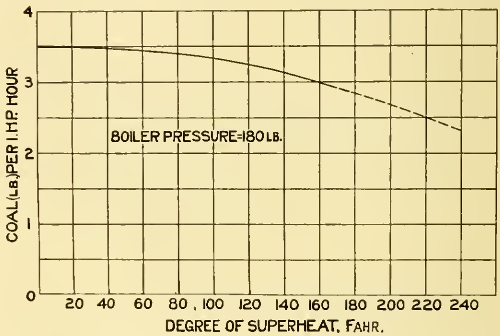



Fig. 3 Curve showing Relation of Coal Consumption to Degree of Superheat

superheater that produces higher steam temperatures; but, from what is above stated, it would not be practical unless it required only a comparatively small sacrifice of evaporating surface. This aim can be achieved with a superheater of a similar parallel flow or firetube type which provides for a still closer juxtaposition of superheater and evaporating surfaces and for an arrangement of superheater surface within still smaller smoketubes than does the present superheater. With such a device, it is possible to obtain a more effective abstraction of heat from the gases and obtain higher superheats without sacrificing boiler efficiency. Such an arrangement is actually in use now in Europe, and its introduction in this country may be possible in time. The hope of further increasing the benefits to be derived from locomotive steam superheating was expressed by George L. Bourne, in his discussion of the report of the sub-committee on Railroads at the Annual Meeting, in December, 1914.

Through systematic efforts on the part of railroads, a number of problems which presented themselves with the introduction of superheated steam in locomotive operation, such as the obtainance of good lubrication, power maintenance at roundhouses, etc., were attacked and successfully solved in a short time; and there appears to be no logical reason why the problem incidental to the use of still higher steam temperatures could not also be solved.

# THE WASHBURN SHOPS OF THE WORCESTER POLYTECHNIC INSTITUTE

BY GEO. I. ALDEN, WORCESTER, MASS.

Member of the Society

THE germ thought to which the Washburn Shops trace their origin doubtless existed first in the mind of Ichabod Washburn, the founder of the Washburn and Moen branch of the American Steel & Wire Company, at present a branch of the U. S. Steel Corporation. The first paragraph in Mr. Washburn's letter of gift to the Trustees of the Institute reveals the blending of purely practical, with high moral and ethical, ideals. He says:

"I have long been satisfied that a course of instruction might be adopted in the education of apprentices to mechanical employments, whereby moral and intellectual training might be united with the processes by which the arts of mechanism, as well as skill in the use and adaptation of tools and machinery are taught, so as to elevate our mechanics as a class in the scale of intelligence and influence, and add to their personal independence and happiness, while it renders them better and more useful citizens, and so more like our Divine Master, whose youth combined the conversations of the learned with the duties of a mechanic's son, and whose ideas and teachings now underlie the civilization of the world."

It was long before this letter was written that Mr. Washburn had conceived the idea of a school for apprentices. He had conferred with Rev. Seth Sweetser, D.D., about his plans, but during the Civil War the project "slumbered." Before the consideration of this plan of Mr. Washburn's was revived, John Boynton of Templeton, Mass., had offered $100,000 to endow a school to be located in Worcester. Mr. Boynton's gift was accepted, and a corporation was formed fifty years ago. Trustees were chosen, who made plans for the new school which were such as to include Mr. Washburn's ideas. Mr. Washburn finally very heartily consented to build and endow the Washburn Shops as a department of the Worcester County Free Institute of Industrial Science, now designated more briefly as the Worcester Polytechnic Institute. In doing this, he relied upon the other departments of the Institute to do the purely academic work required in the instruction of the apprentices.

In his letter of gift, Mr. Washburn provided for the appointment of a superintendent of the shops, specifying quite fully his duties. He recognized that the plan was an experiment, and stipulated that in case the trustees felt that the plan proposed could not be successfully and advantageously carried out, that it might be abandoned and the funds given for the support of the shop might be used for the benefit of the "main design of the Institute," mentioning the department of Mechanical Engineering in that connection, and stipulating that in such case a part of the income of the funds should be given to needy and deserving students to aid them in pursuing their education.

The purpose of the establishment of the Shops, as it existed in the minds of Mr. Washburn and the original trustees of the Institute, was to combine more closely theory and practice in the teaching of engineers. Mr. Washburn desired and enjoined that the apprentices should have instruction in the school in those branches of science that had a bearing upon their problems and work in the shop. The trustees intended that, by means of the shop practice, the students should be taught how to make their knowledge of science valuable to the industries of the County; that they should combine skill in the methods and practices of the mechanic arts with adequate knowledge, intelligence and understanding of the sciences underlying these processes.

The first notable achievement of the Shops is their continued existence and usefulness, although the establishment of the Shops as a part or department of the Institute was clearly recognized by the founder and original trustees as an experiment. Indeed, the lines upon which the Institute itself was planned were, for those times, so original, and such a departure from recognized types of education, that the trustees declared their unwillingness to put in charge of the Institute, either as President or the heads of the leading departments, any of the experienced and successful educators of that time; for they realized that the traditions of the established educational routine had such a hold upon the men who had espoused the cause of education, that any plan which included any radical departure from methods then existing would have little chance of success under the direction of the trained and experienced educators of that day.

If there were some who acquiesced in the value of technical training, there were apparently none who could tolerate instruction in a commercial shop or could see any connection between commercialism and education. They felt that there could not have been anything learned in making a product that was afterward sold. The aim, however, in making the goods in a commercial shop was not primarily to sell them, but to have them made by correct methods and up to commercial standards. They would be fit for the market, and, being fit, would likely be sold. The fact that the student knew that the goods he helped to make were standard, and not destined to find their way immediately to the scrap heap, had a fine influence upon the mind and the work of the students.

The second achievement is that the Shops have proved that it is possible and practicable for commercial shops devoted to instruction to be largely or entirely self supporting. The record shows that there have been periods in the history of the Shops during which even a considerable balance of profit has been shown. This condition requires more than simply manufacturing goods that go into the market; it means the highest order of business management and that the shop must have a business. It means that the students may learn in such a shop not simply the correct mechanical processes, but how to produce at a profit and that an opportunity is given the student for instruction and practice in

Presented at a meeting of the Worcester local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on June 8, 1915, in connection with the Celebration of the 50th Anniversary of Worcester Polytechnic Institute.

shop administration and management coincidentally with the period of his scientific and cultural studies.

A third achievement is that the Washburn Shops, by their plan and practice, have established the fact that the only place in which to teach successfully the application of science to the mechanical industries is the commercial shop. Every argument used in the years around 1870 in support of the plan of Mr. Ichabod Washburn and the trustees of the Institute is used today by the advocates of practical training for engineers.

The fourth achievement of the shops by which they must be mainly judged as an educational force is their benefit to the students who have been trained in the shops. The persistence of the shops through a long period of opposition; their financial record; their sound principles; all these are not to be regarded as ends in themselves, but only as the means to the attainment of a much higher aim, viz.—a better

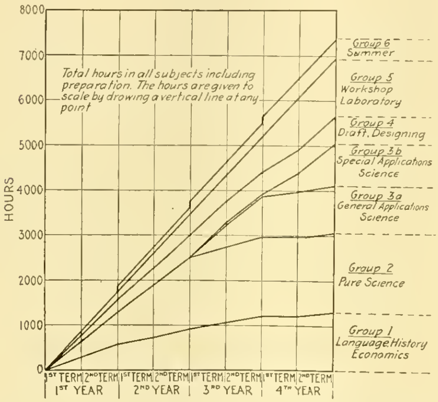



Fig. 1 Chart showing Distribution of Hours in Mechanical Engineering at Worcester Polytechnic Institute

type of education for young men pursuing the study of mechanical or allied branches of engineering. The shop courses, covering operations in cabinet work, in pattern making, moulding, core-making, smelting, and all foundry processes, forging, blacksmithing, machine shop practice, machine design, selection of suitable material of construction, care of tools, familiarity with the materials for water and steam piping, care and operation of steam boilers, steam and other engines, handling of repair jobs, experience with cost systems, accounting, efficiency methods, as applied to the organization of business and the production of manufactured products; all these and other kindred features have, by general consent, resulted in great benefit to the more than 700 students who have graduated from the Department of Mechanical Engineering at the Institute, not to mention those who had shop training in connection with their course in Electrical Engineering.

The shop instruction and practice, however, have never taken the place, or reduced the amount of, instruction in the theoretical studies and in laboratory work, either in range or quantity below that of other first rank technical schools. In illustration and proof of this statement, I am permitted by President Ira N. Hollis, of the Worcester Polytechnic Institute, to refer to his article entitled "Technical Education for the Professions of Applied Science," to be published by the Engineering Congress of the Panama Exposition. He compares the course in mechanical engineering in the Massachusetts Institute of Technology, the University of Michigan, and the Worcester Polytechnic Institute by giving the total hours in all subjects, including preparation. The studies in each school are divided into seven main groups, as follows:

Group 1 —Language, History and Economics
" 2 —Pure Science
" 3a—General Applications of Science
" 3b—Special Applications of Science
" 4 —Drafting and Designing
" 5 —Field and Laboratory
" 6 —Summer Work
" 7 —Physical and Military

The total hours in each group and for each of the schools mentioned, are approximately as follows:

| | Wor. Poly. Inst. | Mass. Inst. Tech. | Univ. of Mich. |
|---|---|---|---|
| Group 1 | 1300 hr. | 850 hr. | 1200 hr. |
| " 2 | 1750 " | 1550 " | 1500 " |
| " 3a | 1100 " | 1250 " | 900 " |
| " 3b | 900 " | 925 " | 1950 " |
| " 4 | 550 " | 550 " | 250 " |
| " 5 | 1250 " | 625 " | 650 " |
| " 6 | 500 " | .... | 300 " |
| " 7 | .... | 100 " | .... |
| | 7350 " | 5850 " | 6750 " |

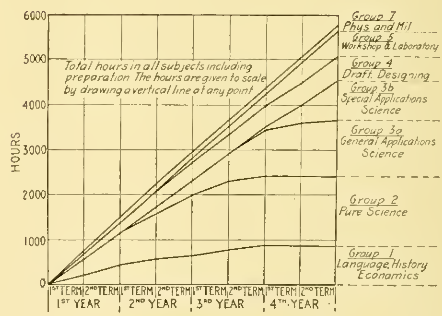



Fig. 2 Chart showing Distribution of Hours in Mechanical Engineering at Massachusetts Institute of Technology

The advantages resulting from a course such as this are many. The fundamental conditions for the type of instruction illustrated by the Washburn Shops are, as we have seen, commercial shops, and the distribution of shop practice throughout the entire engineering course. The first of these conditions secures a degree of shop experience as broad as the shop business permits. The second gives opportunity to bring the theory of the academic work into close and continuous relation to the shop practice. The consideration of the advantages of the commercial shops involves the question of the value and advantage to the young engineer of

shop experience. The manufacturing shops of the country are the connecting link between theory, invention, design, on the one hand, and shop production on the other hand. It is in the shops that theories are modified and perfected, that inventions are made to materialize and become useful, that designs are corrected to conform to the necessities of possible and economical production. The shops stand in a relation to the technical schools of the country similar to that of hospitals to schools of medicine and surgery. Surgeons cannot be produced without hospital practice and experience. The engineer needs to have had shop practice for the same reason that the surgeon needs to have had hospital practice and experience.

That the engineering student should get advantages from experience in connection with so indispensable an agency for the carrying out of all engineering enterprises seems hardly to need emphasis. It may, however, be pertinent to mention specifically some of these advantages:

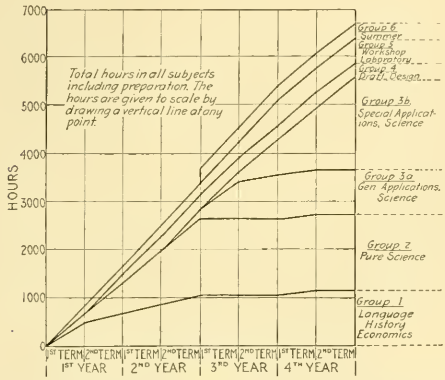



FIG. 3 CHART SHOWING DISTRIBUTION OF HOURS IN MECHANICAL ENGINEERING AT UNIVERSITY OF MICHIGAN

*First.* The possession of mechanical skill has a value which is sometimes much underestimated. It gives one confidence in himself as an independent producer of something worth while—of something which has pecuniary value to him. It gives the young engineer a much better start and insures him a more rapid advancement in his profession. It enables one to direct mechanical operations with confidence and success, and thus gives the young graduate an entrance to one of the most important and promising fields for advancement, viz., the directing and management of skilled men. This is of particular value to men who hope to have a manufacturing business of their own.

*Second.* Shop experience helps one to get an early start in his profession. The most common question, and often the most pathetic as well, which confronts the graduate is, not what do you know, but what can you do? The man with shop experience of the kind under present consideration can say to the employer, in answer to this question, I can make patterns; have done some work in a commercial foundry; can operate ordinary machine tools; can install a system of keeping costs of production; make working drawings for use in an up to date shop; and if you are likely to have any employment in other lines of engineering work for which my education has also fitted me, I would be glad to start at almost any practical work that offers. To be able, in consequence of shop experience, to make such an answer, may be, and very often is, the key that opens a door of wide opportunity.

*Third.* The economy of time which is secured by gaining shop experience from weekly practice in a commercial shop, during the whole period of technical training, is an advantage to the engineering student. The graduate who has had this shop experience may have saved a year or two of time in getting established in his profession or business.

The advantages already mentioned of shop experience are those that mainly accrue to the individual student or graduate. We turn now to a broader subject, the design and standardization of machines or structures and their parts, including the necessary jigs, tools, and accessories. It is in these matters that the engineers, who have risen to high positions without mastering the shop regime, are costing the country and the world vast sums of money by compelling manufacturers to make mechanisms in impractical and expensive ways; by failing to incorporate in their designs and drawings standard bolts, screws, nuts, gears, and many other parts that can be purchased for a fraction of what a small lot can be made for; by neglecting to consider and adopt a design for a casting that can be readily handled in the foundry; by introducing fanciful curves and other forms, which add nothing to the value or beauty of the product, but only greatly to its shop cost. The man with the shop training thinks naturally and inevitably of these things. The man who has had no shop experience, unless he be by nature a prodigy in production, thinks less about these matters, and has not the experience to think effectively.

Also, the designing and constructing of material products involves the maintenance of a business organization. Operation of such an organization has become more complex and more important with the prevalence of large business enterprises. The engineer or manufacturer should understand the functions of each department of the business organization which he serves. The commercial shop offers facilities for acquainting the engineering student with the modern methods of business management and business efficiency by giving him practice in the different departments of the business organization, including time keeping, systems of cost accounting, sales management, bookkeeping, store keeping, draughting room practice, cost estimating, and methods of introduction of efficiency systems; in all these and other allied subjects the commercial shop can offer practice valuable and almost indispensable to an engineer who would master his profession and be able to conduct his practice in harmony with and to the advantage of the whole organism of which he happens to be a part.

Schools for teaching the sciences that underlie the industries were founded in this country at dates preceding the founding of the Worcester Polytechnic Institute, as, for example, the Rensselaer Polytechnic Institute in 1824, and the Lawrence Scientific School in 1847. Hon. Samuel A. Eliot was an able advocate of the plan of offering more advanced scientific courses at Harvard; and, while he was treasurer of Harvard College, the governing boards of Harvard University approved a plan for the establishment of an advanced school of science and literature to be called the Scientific

School of the University at Cambridge; in recognition of the gift by Abbott Lawrence of $50,000, the overseers designated the new school as The Lawrence Scientific School in the University at Cambridge. These schools, and others founded later, all provided for instruction in the sciences that were considered practical, in the sense that a knowledge of these branches of science was necessary to the development of the great engineering, mining, transportation, and other industries.

The result of the training of these schools was a body of educated scientists and engineers. The carrying out of their ideas required a great body of skilled workmen. These workmen were trained by being apprenticed to the various trades. The educated scientists had usually no skill or knowledge of practical, mechanical or construction processes. There was, and to a large extent is today, a broad gap, so far as instruction is concerned, between the trained scientist and the skilled mechanic. This gap has been somewhat narrowed in more recent times by the introduction of laboratories equipped with modern engineering apparatus. But, so far as the training in most scientific or technical schools is concerned, there is still a wide space not yet covered by any well defined system of instruction. In this space have grown up partial and inadequate systems, such as manual training schools, trade schools that do not teach trades, and various independent schools, outlined and directed by almost every grade of talent and attainment except commercial, trade and business experience. But the plan outlined nearly fifty years ago for the Worcester Polytechnic Institute provided for instruction both in the sciences which underlie the industries of the country and their application to the processes and work of the Shops. The plan was harmonious and covered the whole ground. It brought theory and practice together in a direct and simple way. Along with mathematics, pure science and language, the student also would learn the equally important and disciplinary lessons of mechanical skill. While pursuing his engineering studies he would practice production of correct gears, difficult mechanisms, standard machines, prime movers, etc., etc. The adoption of this method of instruction involves connection of some kind with commercial shops; and Mr. Washburn provided for the Worcester Institute this necessary part of the equipment in the establishment and endowment of the Washburn Shops.

The Worcester Polytechnic Institute also has engineering and laboratory courses. It has, as shown in Dr. Hollis' paper, from which we have quoted, all the groups of studies found in engineering schools. It gives more time to instruction and preparation, to both the preparatory and the engineering studies, than the other typical engineering schools with which comparisons are made. It also has shop instruction and practice added, or as a surplus in the account. This showing ought to correct the misinformed and neutralize the false logic of the unthinking.

The training at the Washburn Shops has been improved and expanded from time to time during the past forty-six years to meet new conditions in business management and manufacturing and educational methods. These unique commercial shops, therefore, now enable the Worcester Polytechnic Institute to offer exceptional advantages to the student in mechanical engineering, the course in which they round out and complete.

# NEW BUILDINGS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

*THE local meeting of the Society in Boston, held March 31, 1915, was devoted to the Engineering Equipment of the New Technology Buildings. An illustrated talk was given by Harry Gay, equipment engineer in charge of the work for Stone & Webster Engineering Corporation, and following this Geo. E. Libbey of the firm of Hollis French & Allen Hubbard addressed the meeting. A. L. Williston, president of Wentworth Institute, concluded the meeting with an illustrated talk on the Lay-out of Educational Institutions. References to the remarks of the first two speakers follow.*

Mr. Harry Gay described in detail, with the aid of numerous lantern slides, the general plan of the new buildings for the Massachusetts Institute of Technology, now under construction, as well as those contemplated, and discussed the proposed equipment of the engineering buildings and science laboratories. He stated that the water supply system received special consideration on account of the large demand of the hydraulic laboratories. The power station will supply alternating current at 2,300 volts, 60 cycles, to a substation for the electrical engineering department where, by means of special transforming and regenerating equipment of 500 k.w. capacity, currents up to 6,000 amperes and voltages up to 100,000 will be available for experimental purposes.

The group of science laboratories, situated apart from the engineering laboratories, will be most complete in their facilities for precise research work in addition to undergraduate instruction. The engineering buildings will also contain extensive hydraulic, steam and chemical laboratories in addition to the electrical department.

George E. Libbey described the heating, ventilating and plumbing arrangements of the buildings. There are three distinct systems of drainage, the sanitary, the rain water, and the underground. The last is for the purpose of keeping the surface water away from the buildings, insuring dry basements. In the plumbing system, continuous venting is employed, a new practice which is rapidly coming into use, as it requires less pipe and is less liable to stoppages. Forced hot water circulation was considered very carefully for this purpose, but a number of conditions governing the installation favored steam, and these were outlined in detail. Among these were the difficulties experienced in obtaining underground tunnels for suitable piping connections.

The heating and ventilating of the group of buildings presented many difficulties on account of the large amount of apparatus in the buildings. A vacuum steam system of heating was decided upon, with which, by means of thermostats operating automatically controlled valves, the temperature can be regulated within two degrees. In connection with the ventilating, supply fans in the basement take air from the windows and apply it to the interior. It is then collected in ducts and exhausted by discharge fans on the roof. The air for ventilation is tempered by primary heaters automatically controlled by thermostats. In the chemical building, the air is changed eight times an hour, and the fumes from the chemical hoods are abstracted through ducts by a special system of fans on the roof. In all, over 100 large fans, requiring 280 kw., are installed.

# TECHNICAL DISCUSSION

## A RATIONAL BASIS OF COMPARISON OF THE DUTIES OF ELECTRICAL ELEVATORS AND HOISTING ENGINES

BY ANDREW M. COYLE, NEW YORK

Member of the Society

THE following brief discussion is intended to make clear the mechanical and electrical conditions which enter into and limit the efficiencies of the several types of electrical elevators and hoists now on the market. In view of the recent discussion of this subject at a local meeting of the Society and the apparent lack of a basis of comparison of these machines, it is hoped that the data here given and the simple algebraic formulae, developed some years ago and recently revised, may furnish a working basis upon which the theoretic efficiencies of the several types of machines, and the several systems of *rigging* or methods of installation, may be compared and the power requirements for any given installation definitely computed.

In general, the engines in use fall into three classes: *a*, worm-geared; *b*, spur-geared, and *c*, direct-driven machines. The worm-geared is the most common form of engine for elevator service, and the spur-geared the most common form for general hoisting purposes. The helical or herring-bone gear is a special form of spur gear, and may be treated as such. The traction elevator is a special form of rope drive, and may be so treated regardless of whether the traction sheave is driven by means of gears or by a directly-attached motor. For convenience of reference, diagrams are given which show the arrangements of rigging most commonly used with electric elevator and hoisting engines.

### EFFICIENCY

As it is desirable to compare the efficiencies of the several types of machine and several methods of installation, it will be convenient to make a general summary of the elements which enter into the problem. An electrical elevator or hoisting installation consists of: 1. A motor; 2. A system of electrical switches and resistances by which the motor is controlled; 3. A drum or sheave driven by the motor, either directly or by means of gearing; 4. A cable transmission to which is attached a car, and usually a counterweight; 5. A brake pulley and brake usually located on the motor shaft; and 6. Certain governing and safety devices which, though of great importance, do not affect the efficiency of the installation. It is quite obvious that electrical engines used for general hoisting purposes will come under the same mechanical laws, and may be treated by the same formulae as are applicable to elevator machines.

The actual efficiency of an elevator can hardly be expressed by a percentage. The conditions under which they operate are extremely variable. The total current consumed by a machine per car mile when performing a specific duty is the only proper basis of comparison.

Economy demands that a machine must use current most efficiently when performing the duty for which it is most frequently used. From this it follows that the machine must be designed with reference to this duty. It follows also that, in cases where the loads to be lifted vary between wide limits, a motor must be selected which will give a fair percentage of efficiency under the varying conditions. Commercial motors which are designed for continuous duty are rarely suitable for elevator service. The attempt to use such motors has led to the installation of a great number of inefficient, costly and unsatisfactory elevators.

It will be convenient to develop a few simple formulae which may be applied generally to determine the quantity of current which should be required to perform any given duty with a machine of any one of the standard types.

The energy developed in the motor is used *first,* to impart motion to the system, and *second,* to lift the unbalanced load in the car. As we develop high car speeds, the proportion of current used to produce acceleration increases until a point is reached at which it is not practicable to bring the car to full speed between floors. This limits the speed of elevators for local service.

The masses to which motion must be imparted are the car, counterweight, load, etc., which move in straight lines, and the drum sheaves, armature, etc., which rotate about their centers. In computing the inertia of a rotating body, we consider its mass as concentrated at the *radius of gyration.* The radius of gyration may be expressed as a fraction of the actual radius, or as a fraction of the distance from the center to some known point which bears a fixed relation to the actual radius.

The radii of gyration of the armature and brake-pulley may be expressed as fractions of their actual radii, but the radii of gyration of the sheaves and of the drum may be more conveniently expressed as fractions of the distance from the shaft center to the cable center. The patterns of sheaves and drums in common use are quite similar. It will be near enough for practical purposes if we use in our formulae the radii of gyration which have been calculated for a sheave and drum of standard design. If in the case of any particular machine the patterns differ radically from those in common use, other values may be calculated. In Table 1, $r$ is used to indicate the radius of gyration which is to be considered as the ratio between the center of gyration and the measurement to which it is referred.

TABLE 1 RADIUS OF GYRATION OF REVOLVING PARTS

When several parts are assembled on one shaft the center of inertia has been computed for the combined masses

| Name of Part | $r$ | $r^2$ |
|---|---|---|
| Sheave carrying two or more ropes | 0.922 | 0.85 |
| Winding drum with attached drum neck, gear center and gear | 0.80 | 0.64 |
| Traction sheave with heavy hub and spokes | 0.80 | 0.64 |
| Brake-pulley with solid web and flange coupling | 0.707 | 0.5 |
| Armature and shaft | 0.707 | 0.5 |

### SYMBOLS USED IN ANALYSIS

- $m$ = Mass in pounds of the car, counterweights, cables, counterbalance chains and attachments, plus the entire live load. (All these parts move with the same speed.)
- $m_1$ = Mass in pounds of all sheaves (excepting the driving sheave in the case of traction machines).
- $m_2$ = Mass in pounds of drum (or traction sheave), drum neck, gear center and gear.
- $m_3$ = Mass in pounds of brake pulley and flange coupling (if coupling is used).
- $m_4$ = Mass in pounds of armature and shaft.
- $m_5$ = Mass in pounds of intermediate gear, in case of machines having double gear reduction.
- $m_6$ = Mass in pounds of cables in motion, in case of machine having 2:1 rigging.
- $M$ = The Mass Aggregate; that is, a mass equivalent to the aggregate of all the masses in the system multiplied by the factors which modify their effective values in the total inertia of the system.
- $M_1$ = Negative Mass Aggregate.
- $v$ = Velocity of the car, in feet per second.
- $v_1$ $v_2$ $v_3$ $v_4$, etc. = Velocities of the centers of gyration of the masses having the corresponding subnumbers.
- $D$ = Diameter of winding drum or traction sheave, in feet, center to center of cables.
- $d_3$ = Diameter of brake-pulley, in feet.
- $d_4$ = Diameter of armature, in feet.
- $d_5$ = Diameter of intermediate gear, in feet (used in case of machine having double gear reduction).
- $L$ = Unbalanced load, in pounds.
- $F$ = Foot pounds energy which must be developed by the motor during the period of acceleration to impart the required velocities to the different parts of the system and to lift the unbalanced load.
- $F_1$ = Foot pounds energy necessary to impart the velocities $v$, $v_1$, $v_2$, $v_3$, $v_4$, etc., to the masses of the system.
- $F_2$ = Foot pounds energy necessary to lift the unbalanced load during the period of acceleration.
- $F_3$ = Foot pounds energy necessary to overcome friction during the period of acceleration.
- $F'$ = Foot pounds energy available to drive the motor during the period of retardation.
- $T$ = Average torque required of motor during the period of acceleration expressed in pounds at one foot radius.
- $T_1$ = Torque required of motor when running at normal speed, expressed in pounds at one foot radius.
- $r_1$, $r_2$, $r_3$, $r_4$, etc. = Ratios which the radii of gyration of the masses having the corresponding subnumbers bear to the measurements to which they are referred (see Fig. 1).
- $t$ = Time in seconds allowed for acceleration from rest to full car speed.
- $R$ = Gear ratio = Number of turns of armature to one turn of drum.
- $R_2$ = Ratio of intermediate gear (used in case of machines having double gear reduction).
- $P$ = Percentage of efficiency of rope drive, including an allowance for friction of sheave bearings and hatchway resistance.
- $P_1$ = Percentage of efficiency of gearing.
- $P_2$ = Percentage of efficiency of the intermediate gears (used in case of machine having double gear reduction).
- $n$ = Number of turns of armature during the period of acceleration.
- $h$ = Height load is lifted during the period of acceleration, in feet.
- $g$ = Gravity = 32.18.

### STARTING CONDITIONS

Using the symbols defined, we may establish certain relations between the values which they represent.

$$F = F_1 + F_2 + F_3 \quad \text{[1]}$$

$$F = 2\pi n T \quad \text{[2]}$$

Since T is the average torque during the period of acceleration and the distance through which the torque acts is $2\pi n$, the above relation is obvious.

$$F_1 = \frac{mv^2 + m_1v_1^2 + m_2v_2^2 + m_3v_3^2 + m_4v_4^2}{2g} \quad \text{[3]}$$

The values of $v_1$ $v_2$ $v_3$ $v_4$ may all be referred to $v$ taken as a unit. The radii of gyration of the drum and sheaves are referred to the distance from shaft center to cable center for the reason that the cable center moves with the velocity $v$. Without considering the diameters of the drum and sheaves, we have:

$$v_1 = vr_1 \quad v_2 = vr_2 \text{ hence } v_1^2 = v^2r_1^2 \quad v_2^2 = v^2r_2^2$$

In the case of the brake-pulley and armature we must consider the gear ratio and the diameter.

$$v_3 = v\frac{d_3r_3R.}{D} \quad v_4 = v\frac{d_4r_4R}{D} \text{ hence } v_3^2 = \frac{v^2d_3^2r_3^2R^2.}{D^2} \quad v_4^2 = \frac{v^2d_4^2r_4^2R^2}{D^2}$$

Substituting these values in equation [3] we have—

$$F_1 = \frac{v^2}{2g}\left((m + m_1r_1^2 + m_2r_2^2 + (m_3d_3^2r_3^2 + m_4d_4^2r_4^2)\frac{R^2}{D^2}\right). \quad \text{[4]}$$

In finding the value of $F_3$, it may be noted: *first:* The power required to impart motion to the armature and brake-pulley is not affected by the efficiency of the machine; *second:* The power required to impart motion to the drum and gear is affected by the efficiency of the gear, expressed by the percentage $P_1$; and *third:* The power required to impart motion to the sheaves, car, counterweight, cables, chains, etc., is affected both by the efficiency of the gear and by the efficiency of the cable transmission $P$. This condition may be expressed:

$$F_1 + F_2 = \frac{v^2}{2g}\left(\frac{m + m_1r_1^2}{P \times P_1} + \frac{m_2r_2^2}{P_1} + \frac{(m_3d_3^2r_3^2 + m_4d_4^2r_4^2)R^2}{D^2}\right) \text{[5]}$$

The quantity in the parenthesis in equation [5] is the mass aggregate expressed by the symbol M. It is the total inertia of the system, including friction, which in this case acts to all intents as an increase of mass.

It is obvious that

$$F_2 = L \times h \quad \text{[6]}$$

By the laws of acceleration

$$h = \frac{1}{2}vt \quad \text{[7]}$$

Hence

$$F_2 = \frac{1}{2}Lvt \quad \text{[8]}$$

The number of turns made by the drum during the period of acceleration will be $n \div R$. The circumference of the drum is $\pi D$; hence we have

$$h = \frac{\pi D n}{R} \quad \text{[9]}$$

From equations [7] and [9] we have

$$2\pi n = \frac{Rvt}{D} \quad \text{[10]}$$

For running conditions, only the friction of the parts and the work of lifting the load are to be considered.

The above considerations lead to the following mechanical formulae:

Energy required for acceleration

$$F = \frac{1}{2}\left(\frac{Mv^2}{g} + Lvt\right) \quad \text{[11]}$$

Average torque required during period of acceleration

$$T = \frac{D}{2R}\left(\frac{Mv}{gt} + L\right) \quad \text{[12]}$$

Velocity which may be imparted in a given time by a given average torque

$$v = \frac{gt}{M}\left(\frac{2RT}{D} - L\right) \quad \text{[13]}$$

Time required to produce a given velocity by means of a motor having a given torque

$$t = \frac{Mv}{g}\left(\frac{D}{2RT - L}\right) \quad \text{[14]}$$

Torque required for running

$$T_1 = \frac{D}{2RP_1}\left((1 - P)(m + m_1 + m_2) + L\right) \quad \text{[15]}$$

which holds until the value in the parenthesis becomes zero. When the quantity assumes a negative value use

$$T_1 = \frac{DP_1}{2R}\left(L - (1 - P)(m + m_1 + m_2)\right) \quad \text{[15a]}$$

In selecting a motor to develop torque necessary to produce acceleration it must be noted that the average torque is not simply a mean between the highest and lowest torque developed during the period of acceleration. The average torque developed by the motor must meet the conditions $T = \frac{F}{2\pi n}$ in which n is the number of revolutions made by the armature during the period of acceleration.

Equation [15] represents the running conditions of geared machines in general. In the case of the direct driven traction machines $R$ = unity and $P_1$ takes into account only the friction of the armature bearings. In the case of the 2:1 rigging the value of $R$ is 2.

The following formulae are derived from equation [5]:

### FORMULAE FOR MASS AGGREGATE

A general formula for the mass aggregate of a machine having a single gear

$$M = \frac{m + m_1 r_1^2}{P P_1} + \frac{m_2 r_2^2}{P_1} + \frac{R^2}{D^2}(m_3 d_3^2 r_3^2 + m_4 d_4^2 r_4^2) \ldots\ldots [16]$$

in which $r_1$, $r_2$, $r_3$, $r_4$ are the fractions which express the ratios between the radii of gyration and the actual radii of the rotating parts. For convenience, these fractions have been calculated for the parts of a machine of standard design and the numerical values substituted in the general formula. Unless the machine under consideration is of unusual design these values are sufficiently accurate.

For machine with a single gear ratio, whether worm or spur gear

$$M = \frac{m + .85 m_1}{P P_1} + \frac{.64 m_2}{P_1} + \frac{R^2}{2D^2}(m_3 d_3^2 + m_4 d_4^2) \ldots [17]$$

For machine having a double gear ratio, either worm or spur gears

$$M = \frac{m + .85 m_1}{P P_1 P_2} + \frac{.64 m_2}{P_1 P_2} + \frac{R_2^2}{2D^2}\left(\frac{m_2 d_2^2}{P_1} + R^2(m_3 d_3^2 + m_4 d_4^2)\right) \ldots\ldots\ldots\ldots [18]$$

For direct driven machine, either winding drum or traction

$$M = \frac{m + .85 m_1}{P P_1} + \frac{.64 m_2}{P_1} + \frac{m_3 d_3^2 + m_4 d_4^2}{2D^2} \ldots\ldots\ldots [19]$$

For geared machine with 2:1 rigging, either winding drum or traction

$$M = \frac{m + 3.4 m_1 + 4 m_6}{P P_1} + \frac{2.56 m_2}{P_1} + \frac{2R^2}{D^2}(m_3 d_3^2 + m_4 d_4^2) [20]$$

For machine rigged 2:1 with direct motor drive

$$M = \frac{m + 3.4 m_1 + 4 m_6}{P P_1} + \frac{2.56 m_2}{P_1} + \frac{2}{D^2}(m_3 d_3^2 + m_4 d_4^2) [21]$$

In formulae [5] and [6] the weight of the traveling sheaves should be included in both $m$ and $m_1$. $m_6$ = only the mass of cables in motion, not the standing part.

### PERCENTAGES OF EFFICIENCY

The values of $P$, $P_1$ and $P_2$ are necessarily approximate. At the outset we must assume that the machines are properly constructed and properly lubricated. The duty performed in the cable transmission during the period of acceleration is much heavier than that performed under running conditions. In order to express $P$ as a percentage of the load in motion we may use the formula $P = 1 - \left(\frac{aw}{m + m_1} + c\right)$, in which $W$ is the total load carried on all the sheaves and on the drum, $a$ is the loss in one sheave expressed as a percentage of the load on the sheave and $c$ is a constant introduced to provide for hatchway friction. The values of P in the diagrams are based on the values $a = 0.03$ and $c = 0.02$. This is a very liberal allowance for starting conditions. For running conditions the values $a = 0.015$ $c = 0.01$ may be used.

The efficiency of a worm gear may be determined by the formula $P_1 = 1 - (a \times \text{cosecant}\ \phi + b)$ in which $\phi$ is the pitch angle of the thread, $a$ the coefficient of friction and $b$ a constant added to provide for the power expended in the bearings and in churning the oil.

The efficiency of tandem or balanced worm gearing is not greater than that of a single worm and gear provided with a good ball-bearing thrust. For light loads, the single gear is preferable for the reason that there is less back lash and less difficulty in setting up the machine and in making repairs.

The efficiency of spur and herring bone gears varies from 0.985 in the case of the best cut gears properly lubricated and provided with anti-friction bearings, to 0.93, which will be developed by any cut gears that are set up with a fair degree of accuracy and moderately lubricated.

TABLE 2 VALUES OF $P_1$ FOR WORM GEAR WITH COEFFICIENT OF FRICTION OF 0.03

| Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 0.734 | 11 | 0.793 | 14 | 0.826 | 17 | 0.847 | 20 | 0.862 | 23 | 0.873 |
| 9 | 0.758 | 12 | 0.806 | 15 | 0.834 | 18 | 0.853 | 21 | 0.866 | 24 | 0.876 |
| 10 | 0.777 | 13 | 0.817 | 16 | 0.841 | 19 | 0.858 | 22 | 0.870 | 25 | 0.879 |

TABLE 3 VALUES OF $P_1$ FOR WORM GEARS WITH COEFFICIENT OF FRICTION OF 0.05

| Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ | Deg. | $P_1$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 0.590 | 11 | 0.688 | 14 | 0.743 | 17 | 0.779 | 20 | 0.804 | 23 | 0.822 |
| 9 | 0.630 | 12 | 0.709 | 15 | 0.757 | 18 | 0.788 | 21 | 0.812 | 24 | 0.827 |
| 10 | 0.662 | 13 | 0.728 | 16 | 0.769 | 19 | 0.796 | 22 | 0.817 | 25 | 0.852 |

Table 2 shows values of $P_1$ for worm gears of pitch angles from 8 to 25 deg., in which the coefficient of friction $a$ = 0.03 and constant $b$ = 0.05. This represents about the best attainable condition.

Table 3 shows values of $P_1$ for worm gears of pitch angles from 8 to 25 deg., in which the coefficient of friction $a$ = 0.05, constant $b$ = 0.05. This represents average practice.

The pitch line of the worm normally slides on the pitch line of the gear. The angles are determined on those lines. As a matter of fact the angle is variable, being greatest near the roots of the threads and less toward the periphery. Worm gears tend to wear more rapidly than herring bone gears. This wear increases the clearance and causes back lash when the load is reversed. This trouble is particularly noticeable in the case of tandem gears. In the case of the direct driven machine there is no gearing, and $P_1$ may be given a value of 0.99 which allows for the friction in the armature bearing.

Referring to the equations [16] to [20] it will be noted

that the mass aggregate is composed of two parts. The high speed component, consisting of the armature and attached parts, and the low speed component, which includes all other moving parts. In all geared machines the power required to impart velocity to the high speed parts is a considerable item. It is important therefore to so proportion these parts as to reduce their inertia as much as possible.

Since the gear ratio and the diameter of the armature both enter into the equation as squares, the natural suggestion is to reduce the gear ratio and the diameter of the armature. We cannot do both; a reduction of the gear ratio requires an increase of torque, which cannot be obtained without an increase in the size and weight of the armature, so the two conditions to some extent balance each other.

Another consideration also tends to offset the gain of a low gear ratio. Owing to electrical conditions, we cannot decrease the surface speed of the armature without in a greater measure increasing its size and weight. Very slow speed motors are inefficient, difficult to control and do not readily meet the conditions of varying load.

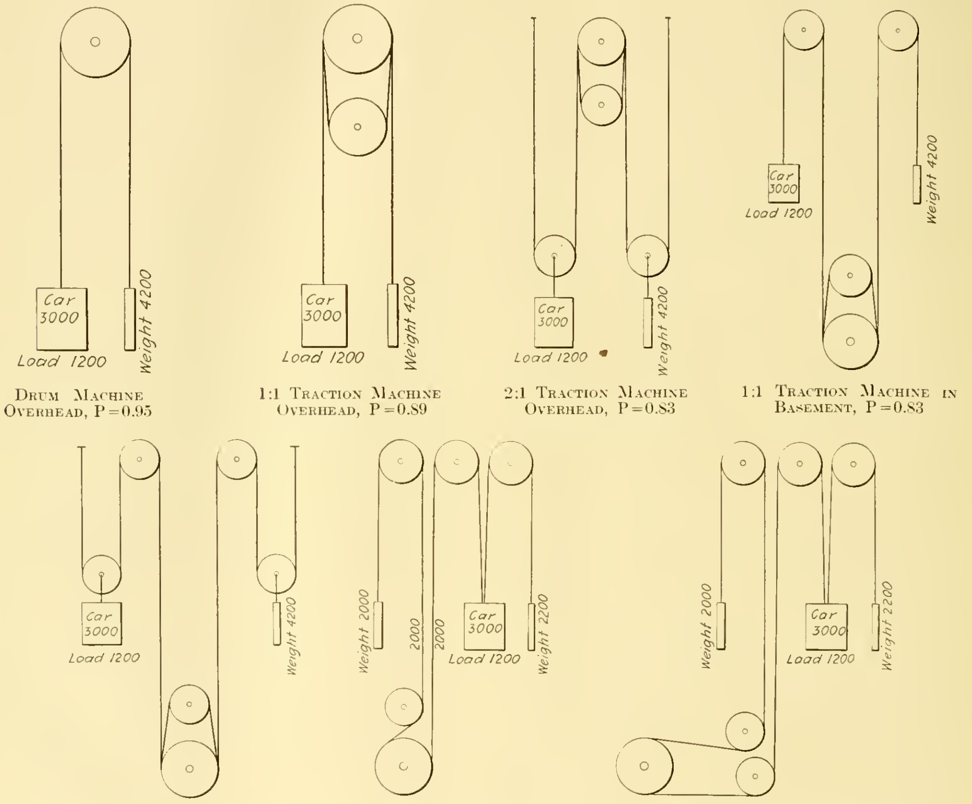
For the purpose of illustration, let us consider the installation of an elevator in a building in which the rise is 250 ft. We will assume that the car weighs 3000 lb., the counterweight 4200 lb., the chains and cables 3200 lb. and that the maximum load is 3000 lb. In this case, the counterweight is 1200 lb. heavier than the car and the maximum unbalanced load will therefore be 1800 lb. The value of $m$ in the formula will be as follows:

For car *running empty*, $m$ = 10,400 lb.

For car with *balanced load*, $m$ = 11,600 lb.

For car with *full load*, $m$ = 13,400 lb.

In a building of the height stated, it would be usual to install a machine of the overhead traction type. We will, therefore, consider:




DRUM MACHINE OVERHEAD, P = 0.95 — 1:1 TRACTION MACHINE OVERHEAD, P = 0.89 — 2:1 TRACTION MACHINE OVERHEAD, P = 0.83 — 1:1 TRACTION MACHINE IN BASEMENT, P = 0.83 — 2:1 TRACTION MACHINE IN BASEMENT, P = 0.80 — DRUM MACHINE IN BASEMENT P = 0.93 — DRUM MACHINE IN BASEMENT, WITH TWO VIBRATOR SHEAVES, P = 0.89

FIG. 1 DIAGRAMS OF THE FORMS OF RIGGING MOST COMMONLY USED SHOWING VARIATIONS IN PRECENTAGES OF ROPE DRIVE EFFICIENCY

FIRST, A direct driven machine; diameter of armature, 32 in. and weight 5000 lb.; diameter of brake-pulley, 36 in. and weight 800 lb.; car speed, 500 ft. per min.; and time of acceleration, 3 seconds.

SECOND, Machine driven by herring-bone gear; diameter of armature, 20 in. and weight 1400 lb.; diameter of brake-pulley, 18 in. and weight 100 lb.; diameter of gear, 36 in. and weight 1000 lb.; gear ratio, 6:1; gear efficiency, 97 per

cent; car speed, 500 ft. per min.; and time of acceleration, 3 seconds.

THIRD, Machine driven by worm gear; diameter of armature, 15 in. and weight 800 lb.; diameter of brake-pulley, 18 in. and weight 100 lb.; diameter of gear, 30 in. and weight 800 lb.; car speed, 300 ft. per min.; time of acceleration, 4 seconds; gear ratio, 24:1; and gear efficiency, 0.86.

In each case we will use a traction sheave 36 in. in diameter, weighing 1000 lb., and an idler 32 in. in diameter, weighing 700 lb. It should be here noted that, in the cases of the geared machines, the diameter of the driving sheave and gear can be increased without increasing the size of the armature. In the case of the direct driven machine this is not possible. The use of a 42-in. sheave slightly increases traction and very greatly decreases the wear on the cables.

Using the weights and diameters above given in the formulae for mass aggregate, we obtain for the car running empty:

*First.*

$$M=\frac{10400+0.85\times700}{0.89\times0.99}+\frac{0.64\times1000}{0.99}+\frac{800\times3^2+5000(\frac{32}{12})^2}{2\times3^2}$$
$$=12478+646+2375=15,499$$

*Second.*

$$M=\frac{10400+0.85\times700}{0.89\times0.97}+\frac{0.64\times2000}{0.97}+\left(\frac{100(\frac{18}{12})^2+1400(\frac{20}{12})^2}{2\times3^2}\right)6^2$$
$$=12736+1320+8228=22,283$$

*Third.*

$$M=\frac{10400+0.85\times700}{0.89\times0.86}+\frac{0.64\times1800}{0.86}+\left(\frac{100(\frac{18}{12})^2+800(\frac{15}{12})^2}{2\times3^2}\right)24^2$$
$$=14365+1340+47200=62,904$$

It is to be noted that the mass aggregate of the geared machine is much greater than that of the direct-driven machine, and that this is chiefly due to the inertia of the high-speed component. The mass aggregate for the balanced load and the full load, if calculated, will appear as in Table 4.

TABLE 4 VALUES OF M, $M_1$, $F$, $F'$, $T$ and $T_1$

(See equations [11], [12], [15], [17] and [19])

| Machine | Start | Stop | Car Ascending | | | | Car Descending | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | M | $M_1$ | F | $F^1$ | T | $T_1$ | F | $F^1$ | T | $T_1$ |
| **EMPTY CAR—1200 LB. OVERBALANCE** | | | | | | | | | | |
| 1 | 15500 | 12627 | 1735 | 28637 | −208 | −1462 | 31735 | −1363 | 3808 | 2700 |
| 2 | 22883 | 18823 | 9059 | 35329 | 194 | −189 | 39059 | 5312 | 794 | 459 |
| 3 | 62904 | 52493 | 12450 | 32463 | 78 | −51 | 36450 | 8463 | 228 | 130 |
| **BALANCED CAR** | | | | | | | | | | |
| 1 | 16862 | 13683 | 18206 | 14780 | 2184 | 879 | 18206 | 14780 | 12184 | 879 |
| 2 | 23673 | 19855 | 25563 | 21443 | 511 | 148 | 25563 | 21443 | 511 | 148 |
| 3 | 64472 | 53405 | 25059 | 20828 | 156 | 42 | 25059 | 20828 | 156 | 42 |
| **1800 LB. UNBALANCED LOAD** | | | | | | | | | | |
| 1 | 18905 | 15264 | 42911 | −6015 | 5149 | 3886 | −2089 | 38985 | −251 | −1678 |
| 2 | 25759 | 21403 | 50295 | −325 | 1006 | 661 | 5295 | 44615 | 106 | −247 |
| 3 | 66824 | 64773 | 43973 | 7263 | 255 | 186 | 7973 | 43000 | 30 | −59 |

In the case of machine No. 1, the armature makes 53 r.p.m. and has a surface speed of 442 ft. per min.; this is a low speed for electrical efficiency and ease of control. In the case of No. 2, the armature makes 316 r.p.m. and has a surface speed of 1663 ft. per min.; this is a good speed both for efficiency and control. In the case of No. 3, the armature makes 760 r.p.m. and has a surface speed of nearly 3000 ft. per min., which is not required for electrical efficiency or ease of control. There is no excuse for using this high speed motor excepting low first cost.

Having found values for $F$, $T$, $T_1$ corresponding to the specified values of $v$ and $t$, we may proceed to the motor. If we are in possession of full data concerning the motors available for use, the formulae will show at a glance the most suitable motor. If no motor at hand will meet the condition, it will be necessary to change either the velocity or the time of acceleration.

It will be convenient to develop a few simple formulae which will give us an approximate estimate of electrical requirements. The following electrical symbols are assumed:

$Q$ = Energy in kw-hr. used per car mile in one direction for all purposes.
$q$ = Energy in kw-hr. used per car mile in making starts.
$q_1$ = Energy in kw-hr. used by motor per car mile running at normal speed.
$q_2$ = Energy in kw-hr. used by the motor per car mile exclusive of the distance traveled during the period of acceleration and retardation.
$q_3$ = Energy in kw-hr. used per car mile during period of retardation.
$q_4$ = Allowance made per car mile for current used in relay and brake magnets (watt-hr.)
$y$ = Energy lost in starting resistance during the period of acceleration (watt-hr.).
$y_1$ = Energy lost in stopping resistance during the period of acceleration (watt-hr.).
$p$ = Percentage of efficiency of motor when operating under overload conditions to produce the torque $T$.
$p_1$ = Percentage of efficiency of motor when operating under running conditions to produce the torque $T_1$.
$K$ = Mechanical equivalent of 1 kw-hr. = 2,654,200 ft.-lb.
$E$ = Line voltage.
$N$ = Number of starts made per car mile.

The items $q_4$, $y$ and $y_1$ depend on the type of control used, and the extent to which the speed of the motor can be governed by field regulation. They are practically fixed quantities which enter into the equation each time the controller operates.

ELECTRICAL FORMULAE

The car makes $N$ starts per car mile and at each start $F$ ft.-lb. of energy are used. We also have to consider the electrical efficiency of the motor and the loss in the resistance:

$$q=\frac{FN}{Kp}+Ny \dots\dots\dots\dots\dots [23]$$

The number of turns made by the armature per car mile is $\frac{5280R}{\pi D}$ and at each turn the energy used is $2\pi T$ ft.-lb.

The running current per car mile will be

$$q_1=\frac{5280\times2RT}{DKp_1}=\frac{RT_1}{251Dp_1} \dots\dots\dots [24]$$

During each period of acceleration and retardation the car travels a distance approximately $\frac{1}{2}vt$ at less than full speed. The total distance traveled at reduced speed in one car mile is $Nvt$ feet. Hence the distance traveled at full speed is $5280-Nvt$.

$$q_2=\frac{2RT_1(5280-Nvt)}{DKp_1} \dots\dots\dots\dots [25]$$

Each time the car stops, a certain quantity of current is either used or generated and a certain quantity is lost in the resistances.

$$q_3=\frac{F'Np}{K}-Ny_1 \dots\dots\dots\dots\dots [26]$$

$Ny_1$ is negative for the reason that it is a loss, deducted from the generated current.

Summing the several equations

$$Q = \left( N\left(\frac{F}{p} - aF^{1}p_1\right) + \frac{2\pi RT_1}{Dp_1}(5280 - Nrt) \right) \div K + \frac{N(y+y_1)}{1000} + q_4 \quad \ldots\ldots [27]$$

When $F$, $F'$ or $T_1$ has a negative value, the part of the equation in which the negation occurs, changes to $Fp$, $\frac{F'}{p_1}$ or $\frac{2\pi RT_1}{D}$ as the case may be. The time required to run one car mile is (5280 — Nt) seconds; $q_4$ is estimated as 2.5 amperes for this time.

Table 5 shows the variation between running aud starting requirements is great. It is easy to see that the motors must have field regulation; a constant field simply would not meet requirements. There are many constant field motors used in elevator service for slow speed machines. In such cases the period of acceleration is unnecessarily long, the motor is heavily overloaded during this period and a great deal of current is lost in the resistances and in heating the armature.

The compound field is good, so far as starts are concerned, but has disadvantages when stopping. The most satisfactory results are obtained with motors having variable shunt fields and provided with interpoles to govern the commutation. The motor selected for machine No. 2 would have field regulation in the ratio of 1:3; that is, from a slow speed of 106 r.p.m. to the full speed 318 r.p.m. The starting resistance would be in use less than 1 second. The resistance necessary to protect the armature at the instant of starting would be about 1.45 ohms. We will assume that part of this resistance is in use one second at each start. A fair allowance for the current converted to heat in this resistance would be 3.3 watt-hr. per start with full load.

Considering the starting conditions of the motor used on machine No. 1, it is evident that field control cannot be applied to any great extent. In the case of this motor a variation of speed of 1:1½ by field regulation might be obtained. That is the slow speed on strong field might be 35 r.p.m. and the full speed 53 r.p.m. Under those conditions resistance would be used in the armature circuit during a period of about 2 seconds.

The slow speed armature has a high internal resistance, and therefore the external resistance necessary to protect it at the start would not be more than 1.27 ohms. We may consider part of this as being in the circuit about 2 seconds at each start. The current converted into heat in this resistance would be 7.2 watt-hours per start with full load. Considering next the current used in stopping. In the case of machine No. 2, the car speed is reduced to 166 ft. per min. by strengthening the field. During this time a small amount of current may be returned to the line. In the case of machine No. 1, the speed of the car is reduced to 334 ft. per min. by strengthening the field. If $F^1$ has a large positive value, the speed must be further reduced by means of resistance parallel to the armature. This resistance passes a current of about 40 amperes across the line for a period, depending on the skill of the operator. This resistance is thrown across the line at every stop. In the hands of a skillful operator, the period of its use will be brief when $F^1$ is small or negative, and will last from 1 to 3 seconds when $F^1$ is large. An unskilled operator may make considerable runs under negative loads, when the motor, which should be acting as a generator in the line, is merely heating resistance and a current of 40 amperes is passing across the line.

It may justly be assumed that the armature parallel resistance is across the line 1½ seconds at each stop with full load, and on this assumption, for machine No. 1, $y_1$ = 8 watt hours.

The characteristics of a motor when running under uniform load are readily obtainable. For the purposes of hoisting machinery, it is, however, equally important to know the characteristics of a motor during the period of acceleration. This data should be obtained in the testing room, in order that a proper comparison may be made between different motors. Data obtained from tests on elevator machines is not specific for the motor.

The questions which these tests should answer are:

*a* Having a given load and a given mass to be accelerated, what is the period of acceleration?

*b* What quantity of current was consumed during the period of acceleration?

*c* How much of this current was used by the motor and how much was lost in the control resistances?

*d* What was the number of turns made by the armature during the period of acceleration?

No motor should be applied to hoisting duty until this data is known.

TABLE 5 VALUES OF $p$ AND $p_1$ EXPRESSED AS PERCENTAGES AND $y$ AND $y_1$ EXPRESSED IN WATT HOURS

| Machine | Empty Car—1200 Lbs. Overbalance | | | | | | | | Balanced Car | | | | 1800 Lb. Unbalanced Load | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending | | | | Descending | | | | Both Directions | | | | Ascending | | | | Descending | | | |
| No. | $p$ | $p_1$ | $y$ | $y_1$ | $p$ | $p_1$ | $y$ | $y_1$ | $p$ | $p_1$ | $y$ | $y_1$ | $p$ | $p_1$ | $y$ | $y_1$ | $p$ | $p_1$ | $y$ | $y_1$ |
| 1 | .50* | .80* | 4 | 6 | .80 | .90 | 5.3 | 2 | .90 | .85 | 5.5 | 4 | .75 | .85 | 7.2 | 1 | .50* | .83* | 4 | 8 |
| 2 | .60† | .82* | 2.4 | 0 | .82 | .92 | 3 | 0 | .92 | .87 | 2.8 | 0 | .77 | .87 | 3.3 | 0 | .60† | .85* | 2.5 | 0 |

* Motor acting as a generator; use $F \times p$. † Small current and low efficiency. The values given are approximately correct for average performance.

TABLE 6 ESTIMATED CURRENT IN KW-HOURS PER CAR MILE

| Machine | | | Empty Car—1200 Lbs. Overbalance | | Balanced Car | 1800 Lb. Unbalanced Load | |
|---|---|---|---|---|---|---|---|
| No. | $a$ | $q_4$ | Ascending | Descending | Both Ways | Ascending | Descending |
| 1 | 1/3 | 0.15 | −0.992 | 8 24 | 3.87 | 12 25 | −1.60 |
| 2 | 2/3 | 0.15 | −1.17 | 7.98 | 2.85 | 11.73 | −3.11 |
| Diff. | 2:1 | 0 | −0.178 | 0.26 | 1.02 | 0.52 | −1.51 |

Average for one round trip under each condition:—Machine No. 1, 4.27 kw per car mile; Machine No. 2, 3.36 kw per car mile. The line to load efficiency of these two machines is nearly equal. The advantage in this particular comparison is with the geared machine, and is largely due to the increased range of field regulation of the motor used with this machine.

From the above, the importance of having full information about the motor, independent of the machine to which it may be attached, is apparent. In conclusion, I wish to state that, while theoretical considerations may not enable us to predict results as accurately as test sheets will show them, no test sheet should be accepted as reliable unless it shows results nearly conforming to calculation based on sound theory.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

In the end of 1912, Max Jakob stated that the determination of $c_p$ of steam as a function of $v$ from the Clausius thermodynamic relation is extremely difficult, since it depends on the curvature of the isobars in the $vT$ diagram, which is very slight and can scarcely be determined accurately. As a result, equations which have $v$ correct to one-tenth of one per cent may lead to values of $c_p$ several per cent wrong. Professor Goodenough, in his paper published in Vol. 34 of the Transactions of The American Society of Mechanical Engineers, has, however, given an equation for deriving $c_p$ as a function of $v$. In the present issue is published an abstract of the report of an investigation on specific heat of superheated steam at pressures from 8 to 20 atmospheres, by Knoblauch and Winkhaus, in which, among other things, it is shown that up to 8 atmospheres, the values from the Goodenough equation differ from those found experimentally by less than 1 per cent; and that even in the region of superheat, at pressures as high as 20 atmospheres, it reaches only 2.5 per cent. As the author states, it is a surprising fact that, notwithstanding the inherent lack of precision in the processes of determining $c_p$ from $v$, the Goodenough equation gives results in such close agreement with observed values.

### THIS MONTH'S ARTICLES

Causes of explosions in air liquefaction plants are discussed. In the same section is given an abstract of a discussion of the theory of wind motors and derivation of a formula for the useful power developed by same.

Data of tests on Diesel engines when running light are given, showing, among other things, the variation of the indicated average pressure as a function of the speed of rotation and load.

In the section Mechanics, are discussed torsional oscillations of an engine shaft; in particular, of a Diesel engine having several cranked members, a flywheel and an additional heavy rotating mass, such as a dynamo. The author gives a general method for the determination of the influence of any number of masses on the vibration of the engine shaft. In the same section is given, in abstract, a statement of the laws of efflux of drops from capillary orifices.

The use of centrifugal pumps on fire engines and a description of the various methods of starting such pumps is discussed in an abstract from a German periodical.

In the section Steam Engineering, in addition to the article on specific heat of superheated steam at high pressures and temperatures above referred to, are given statistical data on boiler accidents in France during 1912 and an abstract of an article on the determination of pressure variations in steam turbines and of dimensions of nozzles by means of the Mollier JS diagram.

In the section on Testing is described the Kapff oil testing machine, and some data are given on the bearing of cohesion and adhesion of oils on their properties as lubricants.

The gas power blower station of the Maryland Steel Company is described in a paper before the American Institute of Mining Engineers.

An abstract of data on tests on concrete, in particular crushing tests and experiences with tremies of various sizes, is reported from the proceedings of the American Society of Civil Engineers.

From the Journal of the Cleveland Engineering Society is taken a very interesting discussion on machine tool development in 1914, showing the trends of development and discussing various new industrial and mechanical features.

The use of electric furnaces for reheating, heat treating and annealing, their field of application and comparative costs, are covered in a paper before the Engineers' Society of Western Pennsylvania.

Henry A. Gardner, in the Journal of the Franklin Institute, reports an investigation of some little understood phenomena in the behavior of paints; in particular, how paints are affected by fungus growths, enzymes and microörganisms.

On a special experimental engine at the University College, Dundee, interesting tests were made on the distribution of heat in the cylinders of a gas engine, reported from an advance paper published by the Institution of Mechanical Engineers.

The subject of pneumatic tubes, both pressure and vacuum, on which there is unfortunately so little published material, is discussed in great detail from rich experimental data by Alec. B. Eason, in the journal of the Institution of Post-Office Electrical Engineers.

Other subjects, such as new methods of the utilization of lignite coal tar, elastic properties of steel at moderately high temperatures, the measurement of the efficiency of domestic fires and handling fuel in extreme climatic conditions, are reported in other sections of the Engineering Survey.

## FOREIGN REVIEW

**Air Engineering**

### Explosions in Air Liquefaction Plants and Their Causes

There have been several disastrous explosions in plants manufacturing oxygen and nitrogen from liquid air. As a rule, it is quite possible to separate oxygen and nitrogen by fractional distillation in the so-called countercurrent apparatus, but it appears, however, that these apparatus are sometimes subject to highly dangerous occurrences.

The pipes of the column apparatus in which the oxygen is separated from the liquid air have to be thawed out at night because of accumulation of ice. This thawing out process is usually carried out with warm water and, in the meanwhile, the operation of the plant is interrupted. In one case, the attendant was busy thawing out the pipes while a laborer was removing the insulating cork. The foreman had most strictly prohibited the use of a torch, but notwithstanding that the attendant did use one, as he was seen carrying the torch inside. Immediately thereafter, there

occurred an explosion which threw aside heavy iron beams, blew up the roof, killed the attendant and did a lot of other damage. The explosion was followed by a fire. It seems reasonable to believe that the attendant approached with his torch too close to the insulating cork of the column apparatus and in this way ignited the mass. Whether the explosion was due directly to the explosive combustion of the cork or was accompanied by the explosion of illuminating gas has not been established. Tests have shown, however, that the extremely porous cork used in this kind of apparatus accumulates in a very short time such large amounts of oxygen in its pores that it becomes highly explosive.

Another explosion which likewise occurred in an air liquefying plant is also of great interest. It occurred in a plant manufacturing from liquid air pure nitrogen to be used for the production of calcium nitrate. In this case the separation apparatus exploded, mortally wounding the foreman. In this apparatus, the air was compressed to four atmospheres, and was thence led to the liquefaction system where it was allowed to trickle in a column apparatus 3 m. high. The nitrogen evaporated while the oxygen collected in two vessels connected by an overflow. In order to free the nitrogen from the last traces of oxygen, a part of the nitrogen compressed to 100 atmospheres flowed in a thin spiral through the countercurrent helix and through the collector filled with liquid air or oxygen, whence it flowed freely into the upper part of the column. While this was done, the last traces of the oxygen contained in the nitrogen were liquified and flowed down into the collector, and this, as well as the column, was equipped with a safety valve which prevented the pressure therein from exceeding 0.5 atmospheres.

The explosion, which caused a large amount of damage, was not due to excessive pressure, as the presence of a safety valve protected it from that. Two separate detonations appear to have been heard and it seems that the collector was the first to be destroyed, whereupon the oxygen flowing out produced an explosive combustion of the insulating silk. After the first detonation, the foreman rushed to the apparatus but was thrown back by the second explosion, and hurled against a compressor. Previous to that another explosion of a similar nature had taken place, which was ascribed to the fact that in some manner or other the air taken in contained traces of acetylene and that copper acetylide, which is highly explosive, was formed. It does not appear likely, however, that copper acetylide would decompose explosively at a temperature as low as that of boiling liquid air.

The author describes a third explosion which destroyed an entire factory and caused a heavy loss of life. The persons who were in the factory saw a bluish flame, similar to that of lightning, start from the ground. Then a big gray cloud of dust was seen and finally a tremendous detonation was heard, after which the building practically collapsed. Some of the bodies recovered from the ruins were found to be terribly mutilated. The separation apparatus had entirely disappeared and there was an immense hole in the wall near which it stood. From the testimony of the workmen who were in the factory just previous to the explosion, the following is what apparently occurred: The chief engineer and his assistant had started the plant in the morning and it appeared to be working all right. They forgot, however, to blow off the dew which accumulated in the apparatus after it had been standing idle over Sunday and had become somewhat warm. Notwithstanding the most careful cleansing of the air previous to its admission into the liquefaction system, a certain amount of water settled down as ice in the separation apparatus; this had to be melted and removed from time to time. A couple of hours after the plant was started, the foreman inspected it and found everything in order, but apparently the apparatus had simply frozen. When the engineer, who was working the apparatus alone, did not know what to do, he went to the superintendent and was ordered by him to thaw out the apparatus, the superintendent then withdrawing to take care of his clerical work. The engineer, however, notwithstanding strict orders not to bring any fire or hot objects near the apparatus, heated, by a torch, up to red heat, a large wrench used for tightening the stuffing boxes of the expansion valves, and put it into the expansion valve when the insulation of the apparatus apparently caught fire.

Some other cases of explosions in air liquefaction plants are likewise described. From all these, it appears that the causes of explosions may be divided into two classes—one, which is obvious, produced by the prohibited use of an open flame, and the other, less obvious, due probably to some sort of chemical action or freezing.

The author calls attention to the following facts as serving as possible explanations of explosions of the second class. Essentially, air consists of a chemical mixture of oxygen and nitrogen, in addition to which there are present in it, water vapor, carbon dioxide, complex gases and the so-called noble gases, such as argon, metargon, helium, xenon, neon and krypton. The essential properties of these noble gases are that they apparently do not enter into any chemical combination either among themselves or with other gases. The most important of them is argon, of which there is present in the air approximately 0.935 per cent by volume. It liquefies at — 186 deg. cent.; oxygen at — 184 deg. cent. and nitrogen at — 194 deg. cent. In apparatus where nitrogen is produced and where, therefore, a very low temperature has to be maintained, it is quite possible that argon settles down in the pipes, forms an ice-like mass and in this way bottles up the air passages, thus raising the compression of the gas up to the point where it explodes the apparatus.

It is also possible that argon brings about explosions in another manner. Essentially, the noble gases have not a molecular, but an atomic structure; that is, they consist of single atoms. It is, however, possible that this structural property changes at very low temperatures, and in the argon ice the atoms of the gas combine into a complex gas, which dissociates explosively when the temperature rises. Similar explosive dissociations may also take place in the case of peroxide of hydrogen and ozone.

Another source of danger which may cause explosions is the presence of combustible substances in the liquefied air, due, for example, to the penetration of oil from the compressors or perhaps of products of decomposition of lubricating oil formed in the compressors under the influence of the heat of compression. It is also well to bear in mind that in the atmospheric air there are present small amounts of hydrogen and methane, and it is quite possible that if both gases are present in equal amounts they may, after a certain length of time, appear in quite substantial quantities in liquefied air. Considering that air liquefaction plants have usually an output of 400 cu. m. (14,125 cu. ft.) per hour, or 4000 cu. m. per working day of 10 hr., and considering

further that there may quite easily be 0.05 per mil of methane, this would be equivalent to 200 l. (52.8 gallons) of liquid methane, an amount sufficient to create a tremendous explosion in the presence of liquid air or oxygen.

There is one more fact which has to be borne in mind. Ozone may convert hydrocarbons into highly explosive compounds—so-called ozonides or peroxides. Harries produced such explosive compounds even from hydrocarbons having annular formation, such as benzole and toluol, and from other derivatives of methane. Saturated hydrocarbons, such as methane, produce explosive substances of the peroxide type and can be converted into formaldehyde and formic acid. From methane derivatives are also produced ozonides proper, which in most cases are highly explosive, and in the presence of water dissociate into aldehydes and peroxide of hydrogen Unsaturated ketons, aldehydes and single-base acids of fats combine with four atoms of oxygen thereby also forming explosive compounds. It appears, therefore, that unless extreme care is exercised, there are numerous sources of danger in the production of liquid air and its component gases. (*Beitrag zur Klärung der Explosionsursache in Luftverflüssigungsanlagen,* Dr. W. Bramkamp, *Zeits. für komprimierte und flüssige Gase,* vol. 16, no. 12, December 1914, 5 pp. *dp.*)

### Wind Motors

This paper is a discussion of the theory of wind motors, and derivation of formulae for their design.

Considering an element of a wing resulting from the intersection of a wing by a cylinder of radius $r$ having for its axis the axis of rotation $OX$, this element rotates about that axis at a speed of $n$ revolutions per sec., and is subjected to the action of a wind blowing at a velocity of $V$ meters per sec. in the direction of the axis. For all points of that element the relative direction of the wind will be the resultant of the velocity of wind $V$ and the tangential peripheral velocity of the element $2\pi nr$. Denoting the angle of this resultant with the direction $OX$ by $\beta$, we have the relation

$$\tan\beta = \frac{2\pi nr}{V}$$

The element under consideration is directed along the radius $r$, so as to make with the direction parellel to $OX$, an angle $\beta + \alpha$ such that its incidence with the relative wind be $\alpha$. If we project on the axis $OY$ the two components $R_x$ and $R_y$ of the resistance offered to the element by the air in motion, and multiply these projections by the peripheral speed, we shall obtain an expression for the useful power developed by the element, viz.:

$$dP_n = R_y(\cos\beta - \frac{R_x}{R_y}\sin\beta)2\pi nr$$

This can be expressed as a function of $\tan\beta$ (which, for the sake of brevity, is denoted by $z$), in which case we shall have:

$$dP_n = R_yV\left(1 - \frac{R_x}{R_y}\ z\right)z\ \frac{1}{\sqrt{1+z^2}}$$

The resistance is

$$R_y = SW^2K_y$$

where $S = L\,dr$ is the area of the element, $L$ being its width; $W$ the resultant velocity, $= \frac{V}{\cos\beta}$, and $K_y$, unit raising component depending on the section of the element and its incidence $\alpha$; further, the ratio $\frac{R_x}{R_y}$ can be replaced by $\frac{K_x}{K_y}$. If we substitute these values into the expression for $dP_n$, we find:

$$dP_n = \frac{LV^4K_y}{2\pi n}\left(1 - \frac{K_x}{K_y}\ z\right)z\sqrt{1+z^2}dz$$

Assuming that the width of wing $L$ is constant, and is a fraction of the radius, say 1/6, we have

$$L = \frac{r}{6} = \frac{Vz}{12\pi n}$$

where $z$ is that value of $\tan\beta$ which prevails at the top of the wing. Taking further that the wing is made up by placing side by side, along the radius $r$, elements similar to the one just considered, all directed in the same way as it with respect to the resultant of velocities, so that the ratio $\frac{K_x}{K_y}$ is everywhere the same, we can find the formula for the useful power of a wind motor having $a$ wings, by integrating the expression for $dP_n$ between the limits $z_0 = 1$ and $z_1 = Z$:

$$P_n = \frac{aV^5K_yz}{24\pi^2n^2}\int_1^z\left(1 - \frac{K_x}{K_y}\ z\right)z\sqrt{1+z^2}dz;$$

on carrying out the integration between the above limits, we find:

$$\tfrac{1}{3}\sqrt{1+z^2}^{3} - 0.94 + \frac{K_x}{K_y}\left[\frac{1}{8}z(1+2z^2)\sqrt{1+z^2} - z + \sqrt{1+z^2}) - 0.64\right].$$

If we denote by $-A$ the term by which $\frac{K_x}{K_y}$ is multiplied, and by B the second term, we obtain

$$P_n = \frac{aV^5K_yz}{24\pi^2n^2}\left(B - \frac{K_x}{K_y}A\right),$$

where $A$ and $B$ are positive within the limits of integration. This expression shows that as $z$ increases from $z = 1$, the values of $P_n$ are positive, that they start from zero and rapidly increase, and that $P_n$ again becomes zero for a value of $z$ such that $B = \frac{K_x}{K_y}A$. The author shows how the maximum value of $P_n$ is determined. (*Sur les moteurs à vent,* M. Drzewiecki, *Comptes rendus des séances de l'Académie des Sciences,* vol. 160, no. 16, p. 513, April 19, 1915, 4 pp. *tm.*)

## Firing

### New Method of Utilizing Lignite Coal Tar

Lignite coal tar obtained as a by-product from gas producers is usually quite unwelcome because there is no use for it and its elimination involves trouble and expense. Because of its high content of water (up to 40 per cent) it is not commercially profitable to handle. The author in this connection has proposed to reintroduce the tar into the gasification chamber of a producer gas furnace and to gasify it there. This was done and it was found that the otherwise undesirable high water content did not matter here because the water escaped together with the tar, vapors and ammoniacal water and tar coming from the hard coal. A part of the tar vapor, mainly the heavier hydrocarbons, remained, however, in the gas.

The tests were carried out in the following manner: The tar was thrown in the gasification chamber of a producer on the glowing coke cakes and the gas generated in that cham-

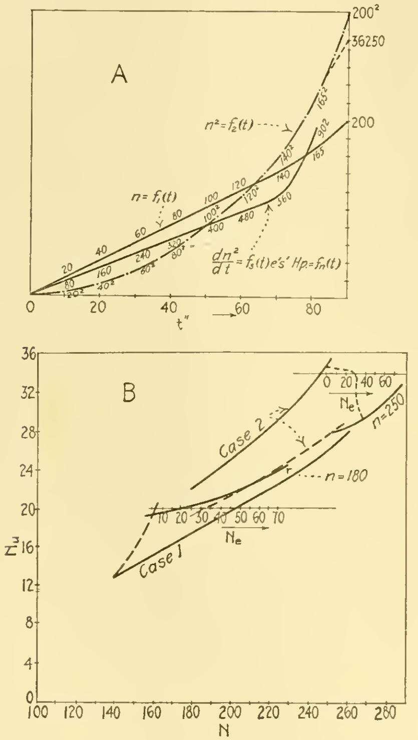
ber was carried away through a separate pipe direct to the apparatus in the testing laboratory, the tar produced in that chamber being also handled separately. The lignite coal tar was added during the period from the 20th to the 23rd hour of gasification; that is, it was stopped just one hour before the taking out of the coke cake. The amount of tar supplied was 100 kg. (220 lb.), approximately the same as is taken out in producer gas production per chamber.

The tests have given the follownig results. Before the beginning of the coal tar additions, the gas had an average heating value of 3580 calories (6444 B.t.u. per lb.) at zero deg. cent. and 760 mm. barometric pressure. During the period of addition of the tar it stood around 3950 calories (7110 B.t.u. per lb.), which indicates that unless the lignite coal tar were added, the heating value of the gas during these three hours would, instead of rising, have sunk from 3580 to 3420 calories and probably even below that. The author shows further that the gases produced from the tar were equivalent to 229,600 calories, equal to 44 cbm. of gas of 5200 calories (9360 B.t.u. per lb.).

The author goes through a detailed calculation and shows that in the above escaped gas the lignite tar had at least a value of 3.40 marks per 100 kg. ($0.36 per 220 lb.). (*Ueber ein neues Verfahren zur Verwertung des Braunkohlenteers,* Viktor Schon, *Journal fur Gasbeleuchtung,* vol. 58, no. 17, p. 216, April 24, 1915, 2 pp. *d.*)

### Tests on Diesel Engines when Running Light

No-load runs on Diesel engines can be classified in three groups: *First,* no-load runs without ignition in the cylinder, which occur, for example, when, in a two-cylinder motor, one cylinder drags the other; *second,* no-load runs with ignition but without load, in which case only enough power is developed in the cylinder to overcome friction; and *third,* running light with ignition under load on the engine.



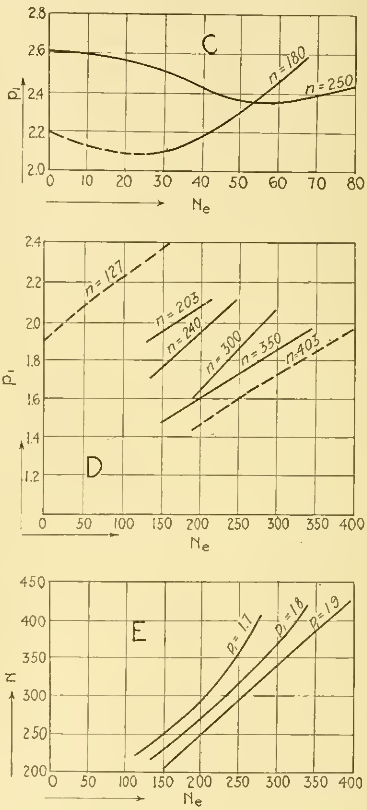




Fig. 1 Curves from Tests on Diesel Engines when Running Light

The no-load run proper is necessary to overcome all the internal resistances and depends, therefore, partly on the design and partly on the workmanship of the engine. The action of the flywheel has to be considered separately in this connection, as, because of air friction and windage, it often takes up quite a considerable amount of horse-power, increasing as the third power of the speed of rotation. With our present state of experimental information on this matter, it is difficult to determine analytically the amount of power consumed by a flywheel, while it is also difficult, if not impossible, to carry out a comparative test without a flywheel. If the speed of rotation is constant, the influence of the flywheel may naturally be neglected because the amount of work done by the flywheel can hardly vary; otherwise, the re-

sults obtained will be somewhat lacking in precision.

The experiments described below have been carried out on a single cylinder Diesel engine of 50 h.p., on which, by varying the speed, an output as high as 70 h.p. could be secured.

The moment of torsion is

$$M_d = Ip\frac{d\omega}{dt} = Ip\frac{\pi}{30}\cdot\frac{dn}{dt}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[1]$$

where $Ip$ is the polar moment of inertia of the flywheel in kgm. sec.$^2$, $\omega$ the angular velocity in sec.$^1$, and $n$ the r.p.m.

TABLE 1 DIESEL ENGINE RUNNING AT LIGHT LOAD

A

| $t^u$ | $n$ | $\frac{dn^2}{dt}$ | $L\frac{\text{mkg}}{\text{sec}}$ | $PS$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 10 | 20 | 80 | 137.6 | 1.84 |
| 20 | 40 | 160 | 275 | 3.66 |
| 30 | 60 | 240 | 412.8 | 5.5 |
| 40 | 80 | 320 | 550.4 | 7.34 |
| 50 | 100 | 400 | 688 | 9 17 |
| 60 | 120 | 480 | 840 | 11 |
| 70 | 140 | 560 | 963 | 12.8 |
| 80 | 165 | 902 | 1551 | 20 6 |
| 90 | 200 | 2280 | 3870 | 51.6 |

B

| $Ne$ | $pr$ | $Nu$ |
|---|---|---|
| 26.2 | 2.09 | 20.3 |
| 40.1 | 2.16 | 20.9 |
| 51 | 2.38 | 23 |
| 61.3 | 2.35 | 22.5 |
| 65 | 2.54 | 24.5 |
| 67.5 | 2.58 | 25.5 |

C

| $Ne$ | $pr$ | $Nu$ |
|---|---|---|
| 0 | 2.62 | 34.8 |
| 24.1 | 2.55 | 34.2 |
| 42.5 | 2.2 | 29.3 |
| 60 | 2.34 | 31 |
| 70 | 2.4 | 32 |
| 80 | 2.44 | 33 |

of the engine. In order to produce this moment of torsion is required the work

$$L = Md\omega = \frac{9.86}{1800}\,Ip\,\frac{dn^2}{dt}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[2]$$

and to calculate $L$, it is necessary to determine $Ip$ and $n$ as a function of time $t$. The value of $Ip$ can be determined either experimentally or analytically, the latter being somewhat uncertain. In the present case, the analytically determined weight of the fly-wheel differed from that determined by actual weighing by 1.4 per cent, which tends to show that the mass used for the determination of $I_p$ has been selected with sufficient precision to satisfy practical requirements. Such a calculation gave for $I_p$ a value of 310 kg.m.sec.$^2$. $n = f_1(t)$ was determined experimentally. The power was shut off, the engine allowed to slow down freely and in 10 minutes the speed of rotation was read by a tachometer. The results obtained in this way are plotted in Fig. 1A as $n = f_1(t)$ (scale 1mm = 0.039 in. = 2 revolutions); $n^2 = f_2(t)$ is also plotted (scale 1mm = 0.039 in. = 250 $n^2$).

By graphic differentiation, the third curve

$\frac{dn^2}{dt} = f_3(t)$ was drawn to such a scale that 1mm = 10.

Equation [2] becomes in this case.

$$L = 1.72\frac{dn^2}{dt} \qquad [3]$$

The results thus obtained are presented in Table 1A, in which the last column gives the power consumption. The last series of figures in this table are not fully reliable, because an element of uncertainty crept into the construction of the tangent. These figures have been plotted on the diagram of Fig. B with the notation "Case I." This curve from $n = 140$ on has been plotted approximatively.

Tables B and C give the data of tests made on the same engine at constant speed: $n = 180$ r.p.m. and $n = 250$ r.p.m. In these tables $Ne$ denotes the effective horse-power, $Nu$, the horse-power at no load, $pr$, the average pressure at no load in kg/cm$^2$ (1 kg/cm$^2$ = 14.22 lb. per sq. in.).

For plotting the curve, ("Case 2"), can be applied only a method in which interpolation is used, because with the present design of Diesel engine a "stationary" no-load operation is very difficult to obtain, and properly conducted tests at no-load always show a higher output of work than at load. By means of interpolation, however, from the actual no-load work can be obtained the "ideal," if, as shown in Fig. B, $Nu$ be plotted as a function of $Ne$ and the curve extended to $Ne = 0$. In this way the dotted curve for the "ideal" no-load work, ("Case 2"), is determined. The actual no-load curve lies above the dotted line and is shown for "Case 2" in full line. If it be desired to draw a comparison between no-load works at different speeds of rotation and at different loads, the indicated average pressure $pr$ must be considered. In Fig. C, the values of $pr$ given in Tables 2 and 3, are plotted as functions of the effective horse-power. This diagram shows that at high loads (that is, *not* at no-load) the indicated average pressure of no-load decreases as the speed of rotation increases. This is shown with particular clearness from Fig. D, representing the data obtained in the tests of Seyliger (*Zeits. des Vereines deutscher Ingenieure*, 1911, p. 587).

These tests are transferred also to Fig. E, where, as abscissae, are used the effective horse-power, and as ordinates, the speed of rotation, the values of $pr$ being assumed respectively constant. These curves show at once that the no-load work, at the same effective load, does not increase in direct proportion to the speed of rotation, but remains somewhat below proportionality. Nevertheless, the mechanical efficiency for the same value of effective load must decrease with the speed of rotation. From Fig. E can be seen the values of $pr$ and $n$ for the effective load Ne = 225. Since, however, the indicated work is

$$Ni = C\,p^2\,n$$

where $C$ is constant, and since it increases in the present case, notwithstanding the fact that $Ne$ remains constant, it follows that, while the work increases, the mechanical efficiency decreases. If the speed of rotation increases, the in-

$$\begin{vmatrix} K_{11}+K_{12}-\alpha^2 & -K_{22} & 0 & 0 & 0 & 0 \\ -K_{12} & K_{22}+K_{23}-\alpha^2 & -K_{33} & 0 & 0 & 0 \\ 0 & -K_{23} & K_{33}+K_{34}-\alpha^2 & -K_{44} & 0 & 0 \\ 0 & 0 & -K_{34} & K_{44}+K_{45}-\alpha^2 & -K_{55} & 0 \end{vmatrix} = 0 \ldots \ldots [1]$$

dicated average frictional pressure decreases for the same value of $Ne$, which leads to a lower mechanical efficiency.

Attention must further be called to the fact that the larger the dimensions of the cylinders or the greater the units under investigation, the smaller becomes the value of $pr$. In practice, it has been found that in multicylinder motors, $pr$ per cylinder decreases also.

Further, there must be taken into consideration, also, the influence of the air pump. In the above described tests, the air pump, which plays an important role in the determination of mechanical efficiency, has been taken into account because that corresponded to the actual conditions.

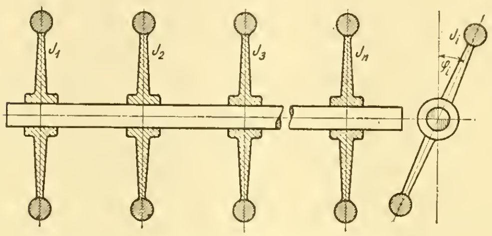



FIG. 2 TORSIONAL OSCILLATIONS OF A DIESEL ENGINE SHAFT

In order to draw comparisons, more precise investigations should be carried out, with and without counting the air pumps. Practically, however, this did not constitute any serious mistake, because the power consumption to the air pump in very large units is negligibly small as compared with the total output. (*Versuche über die Leerlaufarbeit von Dieselmotoren,* Arthur Balog, *Oel- und Gasmaschine,* vol. 15, no. 1, p. 1, April 1915, 4 pp., 7 figs. *et.*)

## Mechanics

### TORSIONAL OSCILLATIONS OF AN ENGINE SHAFT

The article is an investigation of the influence of torsional oscillations on the behavior of a Diesel engine shaft.

In the case of a Diesel engine which developed irregularities in action after passing a certain speed of rotation, it appeared likely that this irregularity may have been due to torsional oscillations. The shaft had four cranked members, a flywheel and, next to it, a dynamo. Therefore, apart from the mass of the shaft proper, these masses might have been taking part in the torsional oscillations; the moments of inertia of the flywheel and dynamo were, however, so much in excess of these others that they should have had a determining effect on the natural frequency of vibration of the shaft. At first glance, it did not seem possible to ascertain how great an influence was to be ascribed to the other masses and this necessitated an analytical method of calculation, which finally led to the method described in this article, permitting the determination of the influence of any number of masses on the vibration of the engine shaft.

Fig. 2 shows diagrammatically a shaft with a fairly large number of masses of which the moments of inertia about the axis of the shaft are indicated by $J_1, J_2 \ldots\ldots J_n$. The number and type of the bearings are not considered here because no attention is paid to the moments of friction; the air resistance exerted on the surface of the rotating masses is also left out of consideration. If a shaft develops free torsional oscillations, it is acted on by moments of torsion which vary by the amount $J_i \dfrac{d^2\phi_i}{dt^2} = J_i\ddot{\phi}_i$, only when the moment of inertia of a mass exceeds $J_i$ and the instantaneous angle of torsion against the vertical (Fig. A) exceeds $\phi_i$. The section of the shaft located between the $i$-th and the $(i+1)$th masses is twisted by the moment of torsion $M_i$ through the angle $\phi_i$ for which case the relation $M_i = C_i\phi_i$ holds good,

By a process of mathematical analysis which has to be omitted here because of lack of space, the author arrives at the following two equations which fully determine the behavior of a shaft under conditions stated above:

and

$\psi_i = \Sigma\, C_k\, \gamma_{ki} \sin\, (\alpha_k t - \delta_k)$

$[i = 1, 2, \ldots\ldots n-1; \; K = 1, 2, \ldots\ldots n-1]$ °

where

$$\frac{C_1}{J_1} = K_{11}; \quad \frac{C_1}{J_2} = K_{12}; \quad \frac{C_2}{J_2} = K_{22} \quad \text{etc.}$$

$\gamma$ with its subscripts refer to constants depending for their magnitudes on the constants of the shaft and masses held on it. The difference of angles (cp. Fig. A) $\phi_2'' - \phi_1'' = \psi_1''$ and $\alpha = \dfrac{\psi_1''}{-\psi_1}$

[1] is an equation of the (n—1)th power for the (n—1) values of $\delta^2$ which can be solved by any known analytical or graphical methods. When forced oscillations arise, one may expect as many resonances as there are values of $\delta^2$. In most cases the minimum value of $\delta$ is of interest, and it can be usually determined approximately. This being done, the determinant of [1] is calculated with several values of $\delta$ near to the value found approximately (which is not difficult even with a large number of masses because of the many zeros in the determinant), and the values of the determinant are plotted on a system of coördinates as a function of $\delta^2$. A curve through the points thus found gives a sufficiently close approximate value of $\delta$.

Actually, because of the damping of oscillations, the greatest deflection will occur with the smallest $\delta$, and even before that the deflections will become excessively large. Further, in order to avoid excessive vibrations, it is necessary to have the smallest periods of free oscillations considerably greater than those of the forced oscillations.

The following example shows the application of the above process. For the case discussed above, it is assumed that the oscillations are due mainly to the action of the flywheel and dynamo, here considered as masses 5 and 6 (the four cranked sections are denoted as 1 to 4). Then, from equation [1]

$$K_{55} + K_{56} - \delta^2 = 0,$$

or

$$\delta^2 = K_{55} + K_{56} = \frac{C_5}{J_5} + \frac{C_5}{J_6}.$$

It was further found that for the flywheel $J_5 = 500{,}000$ kg/cm-sec.$^2$, and for the dynamo $J_6 = 36{,}000$ kg/cm-sec.$^2$,

while $C_5$ (constant for the section of the shaft between flywheel and dynamo) is $1.68 \times 10^8$ kg/cm. Hence

$$\delta^2 = 5006 \text{ and } \delta = +70.8$$

which corresponds to a speed of $\frac{70.8 \times 30}{\pi} = 677$ r.p.m.

The author shows further that the presence of the cranked portions of the shaft does not materially affect the oscillatory process.

Harmonic analysis of the tangential pressure diagram indicates that resonance is likely to occur only with moments of the second or fourth order. It was therefore to be expected that material oscillations would arise at speeds of $n = \frac{677}{2} = 339$ r.p.m., or $n = \frac{677}{4} = 169$ r.p.m. Actually, however, the speed of the engine, because of oscillations, could not be brought above 162 r.p.m. (*Torsionsschwingungen einer Dieselmotorwelle,* Otto Mies, *Dinglers polytechnisches Journal,* vol. 330, no. 6, p. 101, March 20, 1915, 3 pp., 1 fig. *tm.*)

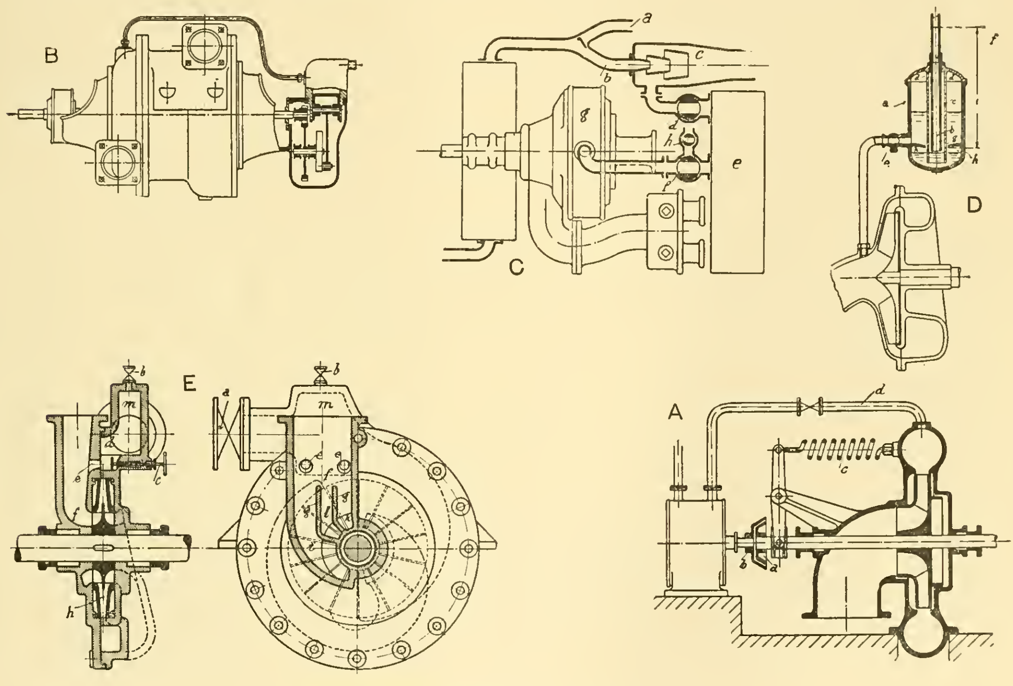



FIG. 3 STARTING DEVICES FOR FIRE ENGINE CENTRIFUGAL PUMPS

### LAWS OF EFFLUX OF DROPS FROM CAPILLARY ORIFICES

In a previous note, the author has shown that the weight of drops escaping from a capillary orifice is a rather complicated function of the frequency of fall. As this frequency increases, the weight of the drops at first increases, passes through a maximum, and then decreases rather rapidly, being, however, at certain critical values of frequency subject to sudden increases so that at high velocities the weight of the drop may be substantially greater than that which it had when it passed through the first maximum.

The author made a series of tests with 15 tubes of different external and internal diameters, the internal diameters varying from 0.4 to 2.4 mm. and the external diameter from 2.3 to 7 mm. He expresses the results obtained in the following four laws:

*First.* The product of the internal diameter $d$ by the interval of time between two drops $T$, corresponding to the first maximum is a constant $A$, or simple multiple of this number. From the frequency zero to that which corresponds to the first maximum, the weight of the drops varies nearly in a straight line with the frequency (after the passage of the first maximum the inverse variation becomes more rapid). This straight line as defined above determines, by extrapolation, the weight $P_\infty$ corresponding to frequency O. This being so,

*Second.* Quotient of the increase of weight $\delta = P_m - P_\infty$ of the drop from the origin to the first maximum by the internal diameter $d$ is a constant number $B$ or a simple multiple of that number.

*Third.* A quotient of the weight $P_\infty$ (at the origin) by the external diameter $D$ is a constant number $C$. $C$ is, however, different from $B$ and in addition to that for tubes for a diameter in excess of 5 mm. it is different from that for tubes with a smaller diameter.

*Fourth.* From the instant of sudden increase of the

weight of the drop, the quotient of this increase of weight or to a simple multiple of it. (*Sur les lois d'écoulement par gouttes par les orifices capillaires*, E. Vaillant, *Comptes rendus des Séances de l'Académie des Sciences*, vol. 160, no. 18, p. 596, May 3, 1915, 3 pp., *te.*)

## Pumps

### Centrifugal Pumps for Fire Engine Service

The article discusses the use of centrifugal pumps on fire engines, a test of such pumps carried out in the Berlin Fire Department Works, the priming of pumps by various means, and their designs.

In Berlin, two types of fire engine equipment are used—one storage battery driven and the other pure gasolene driven. During the recent tests of the storage battery driven engines, it happened that after the engine had been running for about 48 km. (29.8 miles), the current began to give out. The car was immediately shifted into a side street and the battery recharged right on the spot by a gasolene engine intended for driving the pump. For use in case of fire in suburbs, however, engines with a pure gasolene drive are used exclusively.

TABLE 2 VALUES OF $c_p$

| pressure $p$ / temperature of saturation $t_s$ | 0,5 at | 1 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 15 | 18 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 80,9° C | 99.1 | 119,6 | 142,9 | 158,1 | 169,6 | 179,1 | 187,1 | 194,2 | 200,5 | 206,2 | 211,4 |
| $t_s$ | 0.478 | 0,487 | 0,501 | 0,528 | 0,555 | 0,584 | 0,615 | 0,642 | 0,671 | 0,699 | 0,729 | 0,760 |
| t = 110° | 0,471 | 0,483 | — | — | — | — | — | — | — | — | — | — |
| 120 | 0,469 | 0,480 | — | — | — | — | — | — | — | — | — | — |
| 130 | 0,467 | 0,477 | 0,495 | — | — | — | — | — | — | — | — | — |
| 140 | 0,466 | 0,475 | 0,491 | — | — | — | — | — | — | — | — | — |
| 150 | 0,465 | 0,473 | 0,487 | 0,522 | — | — | — | — | — | — | — | — |
| 160 | 0,465 | 0,471 | 0,484 | 0,515 | 0,552 | — | — | — | — | — | — | — |
| 170 | 0,465 | 0,471 | 0,481 | 0,509 | 0,541 | — | — | — | — | — | — | — |
| 180 | 0,465 | 0,471 | 0,479 | 0,503 | 0,531 | 0,567 | — | — | — | — | — | — |
| 190 | 0.468 | 0,471 | 0,478 | 0,496 | 0,522 | 0,552 | 0,588 | 0,635 | — | — | — | — |
| 200 | 0.467 | 0,471 | 0,477 | 0,494 | 0,614 | 0,559 | 0,669 | 0,604 | 0,646 | — | — | — |
| 210 | 0,467 | 0,471 | 0,477 | 0,491 | 0,508 | 0,528 | 0,559 | 0,581 | 0,617 | 0,656 | 0,709 | — |
| 220 | 0,468 | 0,471 | 0,477 | 0,488 | 0,505 | 0,520 | 0,540 | 0,564 | 0,595 | 0.626 | 0,666 | 0,713 |
| 230 | 0.469 | 0,472 | 0,477 | 0,487 | 0,498 | 0,513 | 0.530 | 0,561 | 0,575 | 0,602 | 0,633 | 0,672 |
| 240 | 0,470 | 0,472 | 0.477 | 0,488 | 0,495 | 0,507 | 0,522 | 0,541 | 0,561 | 0,565 | 0,606 | 0,640 |
| 250 | 0,471 | 0,473 | 0,477 | 0,485 | 0,495 | 0,504 | 0,517 | 0,532 | 0,549 | 0,568 | 0,569 | 0,615 |
| 260 | 0,476 | 0,473 | 0,477 | 0,485 | 0,492 | 0,601 | 0,512 | 0.526 | 0,540 | 0,557 | 0,574 | 0,595 |
| 270 | 0,473 | 0,474 | 0,478 | 0,485 | 0,491 | 0 499 | 0,509 | 0,521 | 0,534 | 0,548 | 0.563 | 0,560 |
| 280 | 0,474 | 0,475 | 0,479 | 0,485 | 0,491 | 0,498 | 0,507 | 0,517 | 0,529 | 0,541 | 0,554 | 0,565 |
| 290 | 0,475 | 0,476 | 0,480 | 0,485 | 0,491 | 0,497 | 0.505 | 0,515 | 0,526 | 0,536 | 0,547 | 0,559 |
| 300 | 0,476 | 0,478 | 0,481 | 0,486 | 0,491 | 0,497 | 0,504 | 0,513 | 0,522 | 0,532 | 0,542 | 0,552 |
| 310 | 0,477 | 0,479 | 0,482 | 0,486 | 0,491 | 0,497 | 0,503 | 0,512 | 0,520 | 0,529 | 0,537 | 0,547 |
| 320 | 0,478 | 0,480 | 0,483 | 0,487 | 0,492 | 0,497 | 0,503 | 0,511 | 0,516 | 0,526 | 0,534 | 0,542 |
| 330 | 0,480 | 0,481 | 0,484 | 0,488 | 0,492 | 0,496 | 0,503 | 0,510 | 0,517 | 0,524 | 0,531 | 0,538 |
| 340 | 0,481 | 0,482 | 0,485 | 0,489 | 0,493 | 0,498 | 0,503 | 0,510 | 0,518 | 0,522 | 0,529 | 0,535 |
| 350 | 0,482 | 0,483 | 0,486 | 0,490 | 0,494 | 0,499 | 0,504 | 0,509 | 0,515 | 0,521 | 0,527 | 0,533 |
| 360 | 0,484 | 0,485 | 0,487 | 0,491 | 0.495 | 0,500 | 0,504 | 0,509 | 0,514 | 0,520 | 0,525 | 0,531 |
| 370 | 0,485 | 0,486 | 0,488 | 0,492 | 0,496 | 0,501 | 0,505 | 0,510 | 0,514 | 0,519 | 0,524 | 0,529 |
| 380 | 0,486 | 0,487 | 0 490 | 0.493 | 0,497 | 0,502 | 0,506 | 0,510 | 0,514 | 0,518 | 0,523 | 0,528 |

One of the difficulties to be overcome in the design of a centrifugal pump lies in the fact that the pump is not self-starting, and requires some auxiliary device either for creating a vacuum to raise the water from water level to the pump or for priming. This is done in several different ways; for example, German patent 263,112 employs a rotary air pump coupled directly to the shaft of the centrifugal pump and arranged in such a manner that, after the latter is filled with water, the air pump is automatically uncoupled from the centrifugal pump. As shown in Fig. 3A, on the prolongation of the shaft of the centrifugal pump is placed one-half, *a*, of a removable friction coupling, while the other half, *b*, is on the shaft of the air pump. When the aggregate is at rest, the air pump, because of the action of the spring *c*, is coupled with the centrifugal pump and the rotary part of the latter is displaced towards the suction side. If, however, the aggregate is started, the air pumped through pipe *d* sucks in the air in the centrifugal pump and in the suction piping, and thereby forces the water column to rise by suction. As soon, however, as the water has risen sufficiently, and the blade wheel is enabled to create a difference in pressure between the suction and pressure chambers, there is created an axial thrust on the blade wheel which forces it away from the air pump. The axial thrust is created through the difference in dimensions of the diameters of the lateral packing rings of the blade wheel. When the machine stops, the coupling of the air pump with the centrifugal pump is restored through the action of the spring.

In the estimation of the author considerable difficulty lies in the design of a suitable air pump. The so-called rotary pumps can be applied only with considerable difficulty because of the high speed used here in most cases. Besides, it is difficult to eliminate entirely the axial thrust, which is studiously avoided in all other types of centrifugal pumps. It appears, however, that good results were obtained with this arrangement at low speed, say, 600 r.p.m.

In the fire pump covered by the French patent 435,557 and shown in Fig. B, a special reciprocating pump is used for creating a vacuum in the centrifugal pump. The vacuum pump is built in directly on the centrifugal pump, and in the piping leading from the centrifugal pump to the air pump is placed a cock by means of which the air pump can be shut off from the centrifugal pump. Formerly, there was provided in the same piping a screen to prevent foreign bodies from entering the air pump; the latter is so built, however, that the water that may penetrate into it will do no harm. This pump was once used as an auxiliary pump in a water supply system, and it was found that the centrifugal pump ran for ten days against a suction head of 9 m. (26.2 ft.) without having once broken off the water column.

The German patent 200,765 (identical with the English patent 20,595) utilizes the suction of one or more cylinders of a multicylinder explosion motor for the priming of the centrifugal pump. The patent specifically provides for the interposition of a float in the connecting piping, whereby the entrance of water into the cylinder or cylinders of the motor is prevented. The float valve is arranged in such a manner that, as soon as the rise of water connects with the atmosphere, the further suction of water is stopped. If it proves possible to keep the water from the cylinders of the engine, the practical value of this invention is quite considerable; otherwise, it is of no value.

The French patent 429,270, belonging to the same English concern, utilizes for this purpose the arrangement shown in Fig. D. In the connecting piping is inserted a tank *a* filled up to a certain level with mercury. Around the pipe *b* reaching down into the mercury, is concentrically located the pipe *c*, the lower end of which is immersed in the mercury while the upper end is provided with openings, *d*. With

properly adjusted cocks *e* and *f*, the suction of the air pump forces the water into the tank *a*, delivers it through slot *g* into *h* and causes such a rise in the level of the mercury in pipe *b* that the opening of this pipe is cut off by the mercury. If the vacuum increases still more, the mercury rises to the level *i*, whereby the entrance of the water into the pump is cut off.

Of the several devices utilized for starting centrifugal pumps, the arrangement for maintaining a reserve of water on the pump shown in Fig. E is typical. (Patented in Germany, no. 255,461). Since the suction elbow of the centrifugal pump is directed upward, when the pump is stopped, it remains filled with water, and the pump should start when the cut-off valve *a* is closed, while the air cock *b* and valve *c* are open. In such a case, the water which collects in the pressure space *d* is led through the runner *h*, and along the ribs *g*, this taking place in such a manner that the two spaces *i* and *k* are filled with water while, in the middle space *l*, there occurs an injector-like action due to the fall of water. The mixture of water and air coming from the runner is led into the pressure space *d*, provided with an air reservoir *m*, and from *d* the air sucked in, is allowed to escape through the cock *b*. When water starts to come out from this cock, it shows that the pump is filled with water, then the cut-off valve *a* can be opened and the pump operated in the usual manner.

An interesting design (French patent 400,696) is shown in Fig. C, the fundamental principle of which is the use of the exhaust gases of an explosion motor driving the pump, to drive an ejector by means of which the pump is started. When the pump is to be started, the exhaust gases are delivered into the chamber through pipe *b* into the ejector *c*, not through pipe *a*. (Previous to that the cock *d*, which connects the close water tank with the ejector, has to be opened.) Because of the suction on the water, a vacuum is created in the tank *e*, and this, with cock *f* opened, results in water being sucked into the centrifugal pump *g*. By means of suitable adjustment of the cocks *d*, *f* and *h*, the suction into and the filling of the centrifugal pump can be regulated and the tank can be filled with, or emptied of, water. (*Kreiselpumpen für Feuerlöschzwecke,* Alfred Schacht, *Die Fördertechnik,* vol. 8, nos. 8 and 9, p. 57 and 67, April 15 and May 1, 1915, 8 pp., 14 figs., *d*).

## Steam Engineering

### Specific Heat of Superheated Steam at Pressures from 8 to 20 Atmospheres, and from Temperature of Saturation to 380 Deg. Cent.

For a considerable time, in the laboratory of Technical Physics, in Munich, extensive experiments on the determination of the specific heat of superheated steam have been carried on and gradually extended to cover the region of temperatures up to 550 deg. cent. Recently a boiler became available for use in the laboratory, admitting pressures up to 30 atmospheres gage, which made it possible to enlarge the region of experimentation up to that pressure.

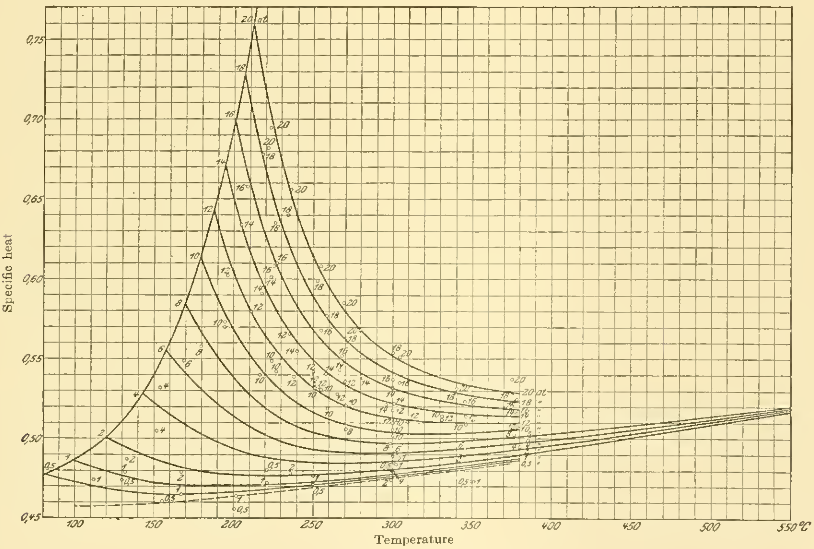



Fig. 4 $c_p$ Isobars in the $c_p$ $t$ Diagram

The formula for $c_p$ is derived in the following manner: Mollier derived for the heat of generation of steam *i* (that is, heat, in kcal., which must be supplied to 1 kg. of steam at 0 deg. cent, to convert it, without altering the pressure, into 1 kg. of steam at *t* deg. cent. and *p* kg. per sq. cm. pressure) the following formula:

$$i = 594.735 + 0.477\, t - J_p$$

where *J* is a function of *t* only, and Mollier gives its numerical values in a table. The small fall-off in pressure [illegible]

corresponding to a small increase in the heat of generation of steam $\Delta i$ is therefore approximately $\Delta i = J\Delta_p$, and since this amount of energy has been taken from a source of electrical heat at the point of the experimental apparatus denoted as $u$, the amount available there for the superheating of the steam becomes $[(W - V) - GJ\Delta_p]$ where $W$ is the total amount of electrical energy shown by the meter, $V$ heat losses, and $G$ weight of steam flowing through per hour. This gives for $c_p$, the following expression:

$$c_p = \left[\frac{W - V}{G} - J\Delta_p\right]\frac{1}{t_2 - t_1}$$

The original article contains a table (Table 2) of values of specific heats calculated by means of the above equation. In Fig. 4 these values of $c_p$ have been plotted as ordinates over temperatures, as abscissae, and curves have been drawn through them connecting points of equal pressure. In plotting these $c_p$-isobars, drawn for 0.5, 1, 2,.... 20 atmospheres certain methods of equalization had to be resorted to, in addition to which the behavior of $c_p$ at the critical point, and the dependence of the total heat $i$ on pressure had to be considered. At the critical point, $c_p$ must become infinitely great. Hence, if all the $c_p$-isobars be extended to the left to the point of saturation, and the terminal points be connected by a curve, this $c_p$-saturation curve will reach at the critical point the value $c_p = \infty$.

The total heat $i$ (which has to be supplied to 1 kg. of water at 0 deg. cent., to convert it at the same pressure into steam of a given temperature) is, at a given temperature, greater for lower pressures than for higher ones. The $c_p$-isobars therefore have to be drawn in such a manner that they give for $i$ values which satisfy this dependence on pressure.

In Fig. 4 is shown, dotted, also the curve obtained by extrapolation for zero atmospheres.

The comparison of these isobars with those of Knoblauch and Mollier for 2, 4, 6 and 8 atmospheres indicates, in the region of superheat, only very slight differences, but on the saturation line the values have to be lowered considerably as compared with the former ones, in order to bring them into accord with those determined at higher pressures.

The author compares his results with those of M. Jakob (*Zeits. des Vereines deutscher Ingenieure,* 1912, p. 1980) and G. A. Goodenough (Trans. A. S. M. E., vol. 34, p. 507), who both start with the Clausius thermodynamic equation, with the difference, however, that Jakob determines $c_p$ from $v$ while Goodenough attempts to do the reverse.

Jakob used an equation of state of steam derived from the determinations of Knoblauch-Linde-Klebe, and, within the region of validity of this equation finds, between values of $v$ calculated from the equation and those determined by measurement, differences below 0.25 per cent, a truly excellent agreement. But at higher pressures in the region of superheat, the deviations of the values of $v$ as determined by the Clausius formula from those found by observation, are much greater, and the difference at 19 atmospheres and 300 deg. cent. amounts to 1.1 per cent.

The agreement between the measured values and those calculated by the Goodenough equation is naturally less close, because, as has been shown in technical literature, the double differentiation in $t$, required in the Clausius formula to determine $c_p$ from $v$, changes very materially the value of $c_p$ even when the error in the value of $v$ has been very slight. Nevertheless, up to 8 atmospheres and 550 deg. cent., the values from the Goodenough equation differ from those found by the author, by less than 1 per cent, but gradually become less as the region of saturation is approached. For average and high superheats, however, the differences between the calculated (from the Goodenough equation) and observed values is not great even for higher pressures, and, e.g., at 20 atmospheres and 350 deg. cent., reaches only 2.5 per cent, the calculated values being the smaller ones.

The authors believe that a slight variation of the Goodenough equation or constants used in it might give as good an agreement for the higher pressures as for pressures up to 8 atmospheres. It is surprising that, notwithstanding the inherent lack of precision in the process of determining $c_p$ from $v$, the Goodenough equation gives results in such a close agreement with observed values.

The authors believe that what has been found in the case of steam as to the dependence of specific heat on pressure and temperature applies also to other gases of which the molecules consist of several atoms. As a matter of fact, Scheel and Heuse have already found, in the case of atmospheric air in the neighborhood of its point of condensation, that $c_p$ increases as the temperature goes down. (*Die spezifische Wärme $c_p$ des überhitzten Wasserdampfes für Drücke von 8 bis 20 at und von Sättigungstemperatur bis 380° C.,* O. Knoblauch and A. Winkhaus, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, nos. 19 and 20, pp. 376 and 400, May 8 and 15, 1915, 9 pp., 7 figs. *etA.*)

### Boiler Accidents in France in 1912

The table below is taken from a compilation from official reports on boiler accidents. The data are tabulated, and give: date of accident; kind and location of plant in which it occurred; kind of apparatus; brief statement of circumstances; number of killed and wounded; supposed cause of accident.

Table 3 is a resume of these data.

(*Bulletin des accidents d'appareils à vapeur survenus pendant l'année 1912. Annales des Ponts et Chaussées,* vol. 24, ser. 9, no. 6, Technical part, p. 626, November-December 1914, 16 pp., *sd.*)

TABLE 3. BOILER ACCIDENTS IN FRANCE IN 1912

| Kind of apparatus: | Number of accidents: |
|---|---|
| Not-tubular (tank) boilers: | |
| (a) external furnace, horizontal | 5 |
| (b) internal furnace, vertical | 1 |
| Fire-tube boilers: | |
| external furnace, semi-tubular | 1 |
| internal furnace, direct fired | 2 |
| internal furnace, return fired | 2 |
| Water tube boilers | 7 |
| Superheater | 1 |
| Thermosyphon | 1 |
| Water-gage glass | 2 |
| Blow-off cock | 1 |
| Safety valve | 1 |
| Vessels | 4 |

SUPPOSED CAUSES OF THE ACCIDENTS

| | |
|---|---|
| Lack of care in the riveting of the shell case | 1 |
| Defective manufacture of tubes in semitubular boilers | 1 |

| | |
|---|---|
| Lack of tightness in covers | 4 |
| Defective welding: | |
| of superheater case | 1 |
| of steam collector | 1 |
| Old age, corrosions | 4 |
| Splitting of rivet holes | 1 |
| Overheating due to scale | 3 |
| Excessive pressure due to clogging of valve passages | 1 |
| Overheating to lack of water | 2 |
| Overheating due to unknown causes | 1 |
| Excessive pressure | 1 |
| Improper management and attendance | 3 |
| Breakage of water gage glass | 2 |
| Breakage of the case of the blow-off valve | 1 |
| Lack of strength in locomotive boiler | 1 |

per unit of time, is given, it is possible, when the shape of the blade is likewise given and its cross-section $f$ is known, to determine for every point the value of the right side of the equation of continuity $\frac{G}{f} = \frac{c}{v}$ where $G$ is the weight of steam per second, $f$ cross-section of flow, $v$ specific volume and $c$ velocity. If it be further assumed that the initial state of the steam expanding in the diaphragm is known, then the velocity $c$, at any point of heat content $i$, can be determined from the difference in temperature. If this value be inserted on the right side of the equation of continuity, it serves to determine the specific volume $v$ at that place. It is now possible to determine by means of the curves of equal volume in the JS diagram, on the horizontal line characterizing the heat content $i$, a point for which the specific volume is $v$.

If the same process be repeated under the assumption of different heat contents and the points corresponding to different specific volumes $v$ be connected with each other, then, as Fig. 5A shows, there will be obtained a line curve Y′ Y″, which satisfies the equation of continuity. Further, assuming a certain loss of energy in the blading, the process of expansion may be represented by a curve E E′, which corresponds to the equation of energy. The point of intersection $A_{2d}$ of these two curves satisfies both conditions and characterizes the state of the steam after it leaves the distributor. If $A_1$ denotes the state in front of the distributor and use is made of the velocity of outflow in the preceding stage, then the fall in heat corresponding to this velocity is plotted from $A_1$ up to $A_0$, and the fall $A_0X$ is used as a basis for the calculation of $c$. The second point of intersection $A^x_{2d}$ of the geometric loci is determined for turbines having a velocity in excess of that of sound, while the point S at which the tangent of the Y curve is vertical denotes the entrance of adiabatic velocity of sound.

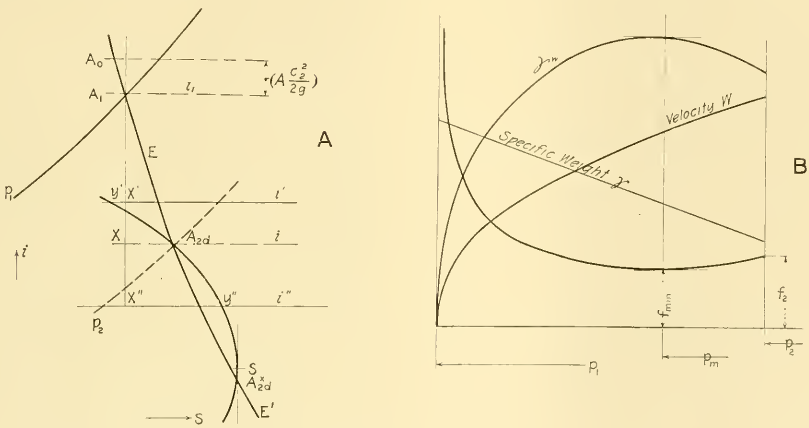



FIG. 5 CURVES OF PRESSURE VARIATION IN STEAM TURBINE AND NOZZLES

## DETERMINATION OF PRESSURE VARIATION IN STEAM TURBINES AND OF DIMENSIONS OF NOZZLES BY MEANS OF THE JS DIAGRAM

The present article is an abstract from a book published by Doctor G. Zerkowitz, under the title "Thermo Dynamics on Turbo Machinery" (Thermodynamik der Turbomaschinen).

The author, who uses the JS diagram of Mollier, denotes his process as a method of geometric loci, since for the determination of the state of steam at any point in the turbine, he draws on his diagram two curves, one of which satisfies the condition of continuity, while the other contains all the points corresponding to the equation of energy: $A\frac{c^2}{2g} = i_1 - i_2$ where $A$ is the mechanical equivalent of heat, $c$ velocity, $g$ coefficient of acceleration or free fall, and $i_1$ and $i_2$, the heat contents at two different points of the stream of steam. The point of intersection of these two geometric loci represents the point of state sought for.

The determination of the state of the steam when it leaves the distributor may be used as an example. Under the assumption that the weight of the steam $G$, flowing through

The determination of the process of variation of pressure is of practical value in the investigation of the governing of turbines. If, however, for example, $p_m$ denotes the pressure in front of the $m$-th stage at full load, $pm + 1$ the pressure in front of the $(m + 1)$ the stage under the same con-

ditions, while $p'm$ and $p'm + 1$ denote pressure at part load, then it can be often shown that $\frac{pm + 1}{pm} = \frac{p'm + 1}{p'm}$. Therefore the velocities of outflow in the separate stages are constant. If such is not the case, then the efficiency varies; and also the ratio of peripheral speed to the velocity of steam may deviate more or less from the most advantageous line.

For the graphical calculation of nozzles, the JS diagram may be also used to advantage. For the solution of this problem, a curve of state is used which diverts from the vertical adiabate to the right; then the pressures $p$ are plotted, which can be found from the diagram and correspond to single points (Fig. B). These pressures are plotted

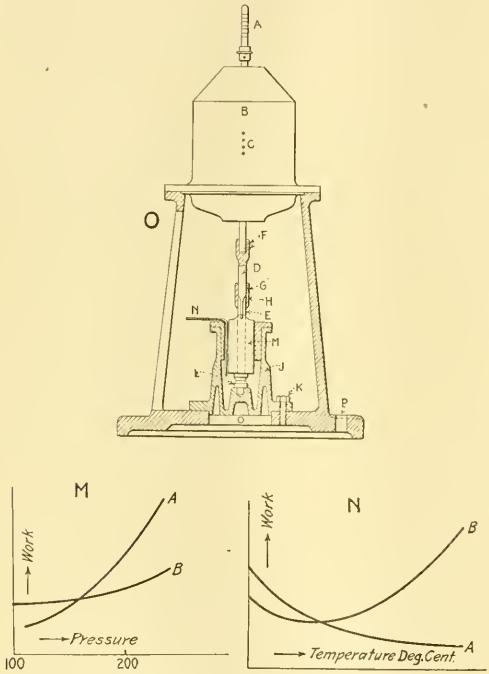



FIG. 6 KAPFF OIL TESTING MACHINE AND CURVES OF TESTS OF OILS

as abscissa, and over them are plotted as ordinates, the specific weights $\gamma$, as well as the velocities $w$, which can be read off on a scale on the side of the Mollier table. Likewise as ordinates the values of the product $\gamma w$ are plotted and then, by means of the equation of continuity, the cross-sections $f$ are calculated and plotted on the diagram.

For practical purposes it is sufficient to determine by the formula the critical pressure; then the smallest cross-section and finally, under the assumption of expansion to any desired counter pressure, the cross-section of the outflow. (*Berechnung des Druckverlaufs in einer Dampfturbine sowie der Düsenabmessungen mit Hilfe des JS-Diagramms*, Schmolke, *Dinglers polytechnisches Journal*, vol. 330, no. 8, p. 152, April 17, 1915, 2 pp., 2 figs. *t.*)

**Testing Machinery**

PROFESSOR VON KAPFF'S OIL TESTING MACHINE

This paper describes the oil testing machine designed by A. von Kapff. While this machine is not new, it is described in detail because it is not mentioned in such works in the English language as "Lubrication and Lubricants," by L. Archbutt and R. Mountford Deeley (London 1912), and "Lubricating Oils, Fats and Greases," by George H. Hurst (London 1911).

The properties of a lubricant essential for the determination of its lubricating value are its cohesion and adhesion. Cohesion, sometimes also denoted as viscosity, is the internal friction of the oil and the thicker the oil, the more work is necessary to overcome this. On the other hand, the ability of the lubricant to maintain a film of oil between the surfaces in friction and thus prevent their seizing and overheating, depends upon the adhesion of the oil. The greater the pressure between the surfaces in friction the greater must be this adhesion, since otherwise the oil would be forced from between the surfaces.

As a rule, in a lubricant adhesion and cohesion go together; that is, when the oil holds well between the surfaces in friction, high internal friction goes with it. In oils of equal cohesion, however, the adhesion may be quite different, and vice versa. Therefore, the determination of the internal friction, which is the only thing that can be made by means of a viscosimeter, gives only a very rough idea of adhesion and value of lubricant as compared with other oils in reduction of power consumption. It is only by means of a regular oil testing machine that this can be done and, for e ample, the two diagrams, Fig. 6 M and N, show to what degree the action of oils depends on temperature and pressure. The oil $A$, Fig. M, consumes at low pressure less power than oil $B$ and is therefore more suitable for the lubrication of spindles or bearings under low pressure, while $B$ is more adapted for high pressure bearings. Fig. N shows two kinds of cylinder oils, $A$, maintaining its lubricating properties at high temperature while $B$ loses its lubricity at about 170 deg. cent. (338 deg. fahr.). Therefore, the fuel consumption and oil consumption with $B$ is considerably greater than with $A$.

The oil testing machine of Professor von Kapff is shown in Fig. O, where $A$ is a speed counter set on the motor axis, consisting of a glass tube, graduated and partly filled with liquid. As the speed increases, the air bubble in the tube comes down, thus indicating the speed. Experience has shown that the best comparable results obtained at speeds varying between 3000 and 7000 revolutions, while spindle oils can be tested at 6000 to 7000 revolutions. The speed is adjusted first by the heavier rheostat $G$ and then by a finer rheostat $F$, actually located on the switchboard. When two oils are tested for purposes of comparison, the speed, temperature and pressure should naturally be the same. When the speed counter is taken off and then put on again, it is important to set it centrally.

In Fig. O $B$ indicates the housing for the electric motor; $C$ are for terminals connected with similar terminals on the switchboard; $D$ is the connecting link between the axis of the motor and the friction spindle $E$, rigidly connected with the motor shaft by means of an adjusting screw $F$ (this $F$, and the following $G$, are different from similar letters used by the author to denote the rheostats). Over the upper part of the friction spindle (fork shaped) is set a bush $H$, likewise

provided with an adjusting screw $G$. When the oil tank $J$ is either taken out or put in again, the screw $G$ is screwed in hard, $H$ lifted up and then screw $G$ loosened. When the tank is set right so that the mark $I$ coincides on the casing with the mark made at the foot of the tank, the screw $G$ is again loosened, $H$ set over the upper part of the spindle and screw $G$ driven in hard once more. The screws $K$ connect the tank rigidly and centrally with the casing. $L$ a thrust journal upon which the spindle runs. The pressure is provided by a separate pressure element $M$, on the upper part of which is located the loading lever not shown in the drawing, $N$ is a thermometer inserted through an opening on top of the tank into the oil. (In Fig. 6 the thermometer is shown bent, but it may also be straight.)

For spindles and transmission, oils are used with temperatures from 20 or 60 to 100 deg. cent. (68 or 140 to 212 deg. fahr.); for cylinder oils, temperatures from 100 to 350 deg. cent. (212 to 662 deg. fahr.). The tank $J$ is filled nearly up to the edge with the oil to be tested. When the oil has to be changed the tank is emptied, washed with kerosene and then with gasoline. For heating the oil in the casing, an opening $O$ is provided under which a good Bunsen burner may be placed.

Before the current is turned on and the motor started, it is well to bring the oil up to approximately the desired temperature; then the speed of rotation is regulated by means of the rheostat until the voltmeter and ammeter have remained stationary for some minutes at the desired temperature and speed of rotation. For regulating the pressure, two weights are provided. Spindle oils and light bearing oils are tested at pressures of about 2 or 3 kg. (28.44 to 42.66 lb. per sq. in.); transmission oils at about 10 to 20 kg. (142.2 to 84.4 lb. per sq. in.) and cylinder oils at 5 to 10 kg. (71.1 to 142.2 lb. per sq. in.). If at a given pressure the apparatus runs irregularly,—that is, if the speed and power consumption vary by jumps,—it shows that for the given oil the pressure is too high. The speed of rotation of the motor should be clockwise when looked at from above. The apparatus is arranged to run on 110 or 220 volts, d.c., and consumes about 1/3 h.p. (*Oelprüfungsmaschine von Prof. von Kapff, Petroleum,* Vol. 10, no. 14, p. 543, April 21, 1915, 3 pp., 4 figs. *d.*)

## ENGINEERING SOCIETIES

### AMERICAN INSTITUTE OF MINING ENGINEERS

*Bulletin, no. 102, June 1915, New York City*

Modern Gas-Power Blower Stations, Arthur West (abstracted).
Fire-Fighting Methods at the Mountain View Mine, Butte, Mont., C. L. Berrien.
Conversion Scale for Centigrade and Fahrenheit Temperatures, Hugh P. Tiemann.

Modern Gas-Power Blower Stations, Arthur West.

The paper describes briefly some recent large blower installations for blast furnaces where the blast is supplied exclusively by gas engines using furnace gas. The following installations are described: Bethlehem Steel Company, eleven engines; Minnesota Steel Company, at Duluth, five engines; Maryland Steel Company, at Sparrows Point, five engines.

The most recent of all of these installations is that of the Maryland Steel Company, and it presents several unusual features. In the first place, although the engines are the same size as those at the Bethlehem and Duluth plants, they are set diagonally in the house, which gives more room around them with the powerhouse 20 ft. narrower. The length of the house is not increased, both because the outboard bearings over-lap each other and because there is room left in the triangular space at the end of the station for a railroad car to enter under the traveling crane, but with engines set squarely across the house at least one extra panel must be provided to allow the entrance of such a car. Because of the lesser span, the costs of both the roof trusses and the traveling crane are likewise reduced.

The arrangement is such that, without moving from the front of the gage board, one man can, single handed, put two engines on the furnace very quickly. The operations are stated as follows: open cold blast valve, (operated by compressed air, controlled from in front of the gage board) to proper furnace, thus letting the blast pressure directly upon the Dyblie automatic check valve on top of the tub; second, by same means, open air snorting valve at side of tub; third, open jacket water valve; fourth, throw in igniter switch; fifth, open gas throttle; sixth, open valve supplying compressed air for starting gas engine. The engine will immediately pick up speed and run under the control of the governor, the tub discharging its air through the snorter out of doors, the Dyblie valve remaining seated under the blast pressure; then, seventh, by means of compressed air, close the snorting valve and the Dyblie valve automatically opens wide and the engine is blowing the furnace. The engine being at all times under the control of the governor, its speed does not vary when it is put on the furnace. It can be put on a furnace very rapidly, always in less than one minute, and the author states that he has seen it done in 35 seconds, with the engine absolutely cold.

It is highly important that the air should be measured into the furnace as carefully and as uniformly as the ore, coke and limestone. A good modern blowing tub with automatic valves is the best known means of measuring air outside a holder. With properly designed air valves, leakage is infrequent, but if there is leakage, it can be easily detected and remedied. The weight of the air delivered to the furnace per minute must remain constant no matter what the variation in the blast pressure. This requires that the engine have tubs designed with the utmost care and that it be equipped with very sensitive speed governors. Sensitive recording speed charts are also installed.

One of the novelties in the design of the plant is that, contrary to the usual practice, the Theisen gas washers have been located directly in the engine room, the idea being that since economical operation of the gas engine is dependent upon the cleanliness of the gas, the chief engineer of the power house ought to be directly in charge of the gas-cleaning apparatus. This arrangement has proved very successful at the Maryland plant. It required only the addition of one bay to the length of the station and saved nearly the whole first cost of the Theisen washers, with its traveling crane, etc. (9 pp., 7 figs., *l*)

### AMERICAN SOCIETY OF CIVIL ENGINEERS

*Proceedings, vol. 41, no. 5, May 1915, New York City*

The Twelfth Street Trafficway Viaduct, Kansas City, Missouri, E. E. Howard
The Picaza Bridge, A. A. Agramonte
Pearl Harbor Dry Dock, H. R. Stanford (abstracted)
The Burden Water-Wheel, F. R. I. Sweeny

Pearl Harbor Dry Dock, H. R. Stanford.

The paper describes in considerable detail the construction of the Pearl Harbor dry docks. Among other things,

the author discusses the concrete used in that construction and describes tests made on them. Only this part of the paper is here abstracted.

Numerous experiments were made to determine the mixture which would produce the most dense and plastic concrete. The ingredients in each mixing were carefully weighed, then mixed with shovels and placed in an 8-in. pipe closed at one end, to determine the volume of the mixture. The degree of density was obtained by comparing the volume with the weight. The plasticity was determined by observing the action of the concrete when handled with shovels and by the settlement into the mass of two wooden rods having sectional areas of 1 and 2½ sq. in. respectively, under the weight of a man.

It was found that, other conditions being the same, the concrete made with the 1 in. stone was more dense and plastic than that obtained with the larger stone. Graded stone, containing such percentages of each size that when

TABLE 4 RESULTS OF CRUSHING TESTS

| Class | Sand | Age | Crushing Strength in Pounds per Square Inch | |
|---|---|---|---|---|
| | | | In Sslt Water | In Fresh Water |
| I | Three parts screenings passing 1/8-in. mesh with dust retained on 30-mesh, with 1 part Puget Sound sand...... | 3 days | 685 | 620 |
| | | 28 days | 1 435 | 1 320 |
| | | 2½ mos. | 1 860 | 2 285 |
| II | Screenings passing 3/16-in. mesh with dust retained on 30-mesh.......... | 3 days | 590 | 470 |
| | | 28 days | 1 280 | 1 230 |
| | | 3 mos. | 1 985 | 1 985 |
| III | Screenings passing 3/16-in. mesh containing all the dust of fracture..... | 3 days | 630 | 565 |
| | | 28 days | 1 505 | 1 390 |
| | | 3 mos. | 2 655 | 2 370 |
| IV | Sand from Puget Sound............ | 3 days | 905 | 845 |
| | | 28 days | 1 745 | 1 780 |
| | | 2½ mos. | 2 450 | 2 360 |

plotted it gave a straight line, produced concrete which was at the same time most dense and plastic. An excess in the percentage of small pieces increased the plasticity but decreased the density, whereas a deficiency in the smaller sizes had little effect on the density but reduced the plasticity. Mixtures in proportion of 1:2.5:4 were more plastic than 1:2:4 but not as dense; 1:2:4 mixtures were more dense than those of 1:2:3.5 but not as plastic.

A series of 132 laboratory crushing tests were made on 6 in. tubes. Nine sets of 12 blocks were made of concrete mixed in proportions of 1:2:3.5, using for each test uniformly graded stones not larger than 1 in. but with differently mixed or prepared sands for the different tests. The results are given in Table 4.

In addition to that, fifteen large-sized test blocks were made under conditions which resembled those actually existing when placing under-water concrete for the bottom of the dock. The concrete for these tests was deposited with tremies in water about 52 ft. deep, the end of the tremie being held near one corner of the form, so that the concrete had to flow an extreme distance of about 6 ft. after leaving the tremie.

A great deal of interesting experience in the use of tremies has been acquired in handling a product at first practically worthless, and then gradually improved until it finally attained a high degree of excellence. Tremies 12 in., 15 in. and 18 in. in diameter were used in these experiments (approximately 14,840 cu. yd. of concrete were deposited through tremies), and the author arrived at the following conclusions:

The results obtained from a tremie depend to a great extent on the proportions, character of materials and plasticity of the concrete which is being used; the excessive frictional resistance to the movement of concrete in a 12 in. pipe causes frequent clogging in the pipe and gradually increases the pressure at the exit, making it impracticable to hold the end of the tremie embedded in the deposited concrete; the frictional resistance to the movement of concrete in an 18 in. pipe is not sufficient to prevent the occasional loss of a charge in the tremie, thereby interrupting the filling of the form, with added uncertainty as to the quality of the product; the frictional resistance in a 15 in. tremie is apparently just about right to obtain the proper discharge pressure necessary for efficiently regulating the flow of concrete by raising and lowering the tremie with the end maintained within the deposited mass. The concrete flows freely to distant parts of the form without causing disturbance in the mass. The tremie 15 in. in diameter is best suited for the work, and in the Pearl Harbor dry dock construction the size was adopted and actually used for placing the greater part of the tremie concrete.

Approved designs, however, eliminated practically all tremie-placed concrete, without involving endangering conditions. This fact is considered a most valuable feature of the plan of construction, inasmuch as there can be no absolute certainty that concrete deposited under water will possess the uniform degree of perfection essential to dock construction. 72 pp., 19 figs. and 25 plates, *de.*)

## CLEVELAND ENGINEERING SOCIETY

*Journal, vol. 7, no. 6, May 1915, Cleveland, O.*



### Some Machine-Tool Developments of 1914, L. P. Alford

The paper presents a very interesting record of the development of machine shop equipment during 1914, from information previously published in *The American Machinist*, of which the author is the editor. The paper cannot be fully abstracted owing to lack of space, and only the most prominent sections are here reported.

One of the questions which the author takes up is whether new machines should be introduced in dull times. On the one hand, there is the desire to stimulate business by offering something new, and the desire to use shop effort, released from the strain of regular production, in developing new ideas. On the other hand, however, the machine tool business is so firmly established on sound engineering principles and firm industrial bases that there is only a very remote possibility that any builder can endanger his competitor's business through the discovery and control of some startling or revolutionary innovation. No manufacturer need fear for his stock because of the new designs of his competitors, but in the introduction of a new design by the manufacturer himself, there is a possibility of dangerous reaction on his own stock in that he can seriously destroy its salability by

bringing out such improvements. In other words, a manufacturer can easily become his own worst competitor. The conclusion is, therefore, that improvements should be brought out when stock is low and that means, in boom times. As one of the speakers (H. M. Lucas) stated in the discussion which followed, "It is well to work out new designs during the dull times, but do not announce them until you get your old stock all sold. Manufacturers usually announce their new designs too soon."

The question of high speed drilling is discussed in detail. Last year, some sensitive drilling machines were put on the market, having spindle speeds as high as 10,000 r.p.m., although experimentally, drilling has been done with speeds up to 20,000 r.p.m. In the larger sizes of machines, 1 in. drills have been successfully run on tests at a speed of 12,000 r.p.m. and a feed of 1 in. per second in cast iron. (The author has seen these tests.)

In high speed drilling with numbered sizes of drills it has been found that the limit of the rate of speed is the muscular activity of the operator. Once the drill has entered, it can be pushed through as rapidly as the operator chooses to move his arm. The tendency of power feeds is toward still higher speeds for small drills than can be obtained by hand, and while the limit of speed has been frequently reached with sewing and shoemaking machines, due to lack of quickness in the operator, with machine tools the operator has always been able to keep up easily with the machine. It appears reasonable, therefore, to expect that the commonly used speeds for drilling and feeds of small drills will be greatly increased within the next few years.

The author discusses in detail the possible limitations in drilling practice. Of these, it appears that the wear of the drill is little affected, in the end, by the speed. The cutting edges of the drill are rather preserved than otherwise, at the higher speeds. As regards heating effects, it is claimed that the total heating effect at high speed is less destructive to drills than at slower speeds. The stresses on the drills are less, the drill is advancing rapidly into the cold metal and as the period of drilling an individual hole is short, the proportion of time that the drill is in the air to the time that it is cutting is increased. It appears, also, that at high speed drilling, less heat will be given to the tool by the chips than at low speed drilling. This is due to a hitherto unexplained fact, namely, that when the chips break off, they are cold and uncolored, but become hot and colored a few seconds later. This action has also been observed in milling and turning.

Increased speed of drilling makes it more important than ever that jigs and work-holding devices should be so designed that they can be rapidly operated. This may mean the use of cams, eccentrics or levers, which are more quickly locked and unlocked than strap and screw-operated devices. Further, increased production means an increase in the rapidity with which chips are produced and jigs must be so made that the chips can be easily brushed or washed away.

The year 1914 has seen the introduction of a system of applying a large amount of lubricant to milling cutters mounted in a rigid machine, whereby peripheral cutting speeds on mild steel ten to twelve times greater than accepted practice (800 ft. per min.) were attained in tests of long duration, with a possible increase in the amount of feed from 30 to 112 in. per min. This system, because of the large amount of lubrication used, has become known as "stream lubrication." Its use is based upon the fact that the heating of the cutter is often *the limitation* to speed, and this can be reduced by using a lubricant or coolant sufficient to remove the heat and keep the cutter and the work cool.

One of the advantages of high speed milling is that it brings the revolution marks closer together, and it is claimed that miller outputs are controlled to-day, in perhaps 90 per cent of cases, by the distance between the revolution marks.

The past year has also played an important part in the development of the so-called "station type" machine, which means a machine in which there is a position for putting in and taking out work and other positions for performing successive operations. While as a tool, it is not new and many machines of this type have been built for special jobs, it was only in 1914 that these machines were brought out for the market in a form to be used on many jobs adapted for a wide variety of work. The needs of the automobile industry have been a feature in developing this line. They have been designed to fulfil the demand for quantity machinery manufacture with unskilled workmen and to make possible an increase of production with a decrease in the accompanying overhead expense.

The main trends of machine tool development in 1914 are summarized by the author as follows: They are toward the use of higher speeds, finer unit feeds, and greater quantities of lubricants; the further development of jigs, fixtures and holding devices which may be operated in a minimum time and the use of highly organized automatic machines, performing a number of successive operations, and suitable to be attended by unskilled labor. (27 pp., 14 figs. *dA.*)

## ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

*Proceedings, vol. 31, no. 3, April 1915, Pittsburgh, Pa.*



### The Electric Furnace for Re-Heating, Heat Treating and Annealing, T. F. Baily

The paper discusses the use of electric furnaces for reheating, heat treating and annealing, both historically and practically.

The type of furnace apparently best adapted for reheating operations is the resistance type in which the material to be heated is entirely separate from and independent of the resistance element in which the heat is generated by the electric current, making it extremely simple and convenient to operate. In some heating operations, the actual cost of heating per ton is less with the electric furnace than with combustion furnaces, while in some heat treating and annealing operations, the precision with which the operations are carried out must be the justification for the higher cost of heating in the electric furnaces. In a general way, it is stated that the higher the temperature at which the heating operation is conducted, the higher the relative economy in the use of electric furnaces. The author sums up the principal advantages of electric furnaces for reheating, as follows: More accurate temperature control; non-oxidizing atmosphere; saving in space; elimination of blast and stack; evenness of temperature throughout the heating space; simplicity of control; smaller amount of heat lost to the sur-

rounding atmosphere; and cleanliness of surroundings. The smaller amount of heat lost to the surrounding atmosphere makes the work around an electric furnace, especially in summer months, far more healthy and agreeable than with the combustion furnace.

The thermal efficiency of electric furnaces vary with the size and capacity in tons per hour, a furnace of 1 ton per hour of 2200 deg. showing an efficiency of 75 per cent. Most of the terminal troubles in electric furnaces for reheating have been practically entirely eliminated; for example, one set of electrodes now lasts for months at a time in continuous service. For furnace temperatures not exceeding 2500 deg. fahr., the electric furnace will answer any reasonable requirements, and, so far as actual fuel cost alone is concerned, at one cent per kw-hr., will compare favorably with oil furnaces burning oil at four cents per gallon.

In large tonnages of heavy billets, the combination of a combustion furnace using producer gas up to 1500 deg. fahr., and heating by electricity from this temperature to the desired rolling temperature offers the advantages of low fuel costs per ton of metal heated and a minimum amount of oxidation of the metal, beside protecting the electrodes. Such a furnace can be expected to show a thermal efficiency in the gas end of 50 per cent, and in the electric end of 75 per cent.

The author discusses, in some detail, the use of electric furnaces for soaking pit and for heat treating and annealing purposes. The type of furnace best adapted to heat treating is the automatic continuous furnace, where the metal under treatment when fired to the predetermined temperature is automatically discharged into the air or into some quenching medium. When the material at the discharge end of the furnace reaches the minimum temperature, a special pyrometer closes an electric circuit, which in turn closes, through a suitable relay, the solenoid-operated radial dial switch, and the various electrical circuits operate, in proper sequence, the doors, pusher and quenching apparatus.

In regard to the economy of small electric reheating furnaces from the fuel point of view alone, where the current consumption per ton is 480 kw. and the rate is one cent per kw-hr., they can be compared with oil where the consumption per ton is 100 gal. at four cents per gallon, or natural gas where the consumption per ton is 12,000 cu. ft. Electric furnaces of the continuous type, of 5 tons per hour capacity, will show a commercial economy over coal fired furnaces of the same capacity with coal at $2 per ton (requiring 200 lb. of coal per ton of steel), while electric furnaces require an electric current consumption of 250 kw-hr. per ton with current at one-half a cent per kw-hr. The combined gas and electric furnace will show a commercial economy, compared with producer gas fired furnace using 200 lb. of $2 per ton coal, while the combination gas and electric furnace uses 140 lb. of coal per ton of metal for heating it to 1400 deg. (30 pp., *gd*).

## FRANKLIN INSTITUTE

*Journal, vol. 179, no. 6, June 1915, Philadelphia, Pa.*

High Temperature Investigation and a Study of Metallic Conduction, Edwin F. Northrup

Sound Steel for Rails and Structural Purposes, Sir Robert A. Hadfield

A Study of Some Curious Painting Phenomena, Henry A. Gardner (abstracted)

An Air Analyser for Determining the Fineness of Portland Cement (U. S. Bureau of Standards)

A Study of Some Curious Painting Phenomena, Henry A. Gardner

This paper includes an investigation of the destruction of paint, especially on buildings, by fungus growths.

The writer noticed that certain types of paint were affected by what is called mildew by painters; not everywhere, but more severely in sections which were shaded by trees or in partially sheltered nooks where dampness would be maintained for considerable periods of time.

Sections of painted surfaces showing marked formation of mildew were collected: In some instances, the mildewed surfaces were lightly scraped with a clean knife and the scrapings collected in a special envelope. A culture medium was then prepared which would exert an inhibitory action upon any ordinary bacteria which might be present upon the specimens, but which would permit the rapid propagation of the fungus spores.

As cypress is one of the most important woods used for construction purposes, especially in the South, where the investigation was carried on, a cypress decoction was prepared in the following manner: 50 grams of finely divided wood shavings were boiled in a half liter of distilled water. The decoction was filtered and ½ per cent of thread agar was added. After steaming to obtain solution, the mass was filtered, tubed and sterilized at 120 deg. cent. for 15 minutes.

The two principal types of fungi which were developed from the mildewed surfaces were shown to be species of *Aspergillus* and *Penicillium*. Tests have shown that black Aspergillus proved the more hardy, while others seemed dormant unless kept constantly moistened. In one test, the black mould, in a week's period, exerted a most destructive effect upon a board coated in white lead with oil, the oil apparently serving as a most favorable medium for this development, and thus playing a leading part in the reaction which results in the destruction of the paint and the exposure of the wood. The development of fungi in every instance was much more rapid upon paint coatings which were soft and subject to retention of moisture, while paints which presented a firm, hard, moisture-shedding surface resisted the fungi and prevented germination of the spores.

The author comes to the conclusion that micro-organisms may play an important role in the behavior of materials of paint, as shown by recent investigations into the causes of certain paint troubles referred to by painters as saponification or washing. This condition is generally indicated by the appearance of a white deposit at the base of porch columns and by the paint assuming a soap-like condition when rubbed. While instances of such action are rare, there was recently an apparent epidemic in one community. The author collected samples of the washed paint for analysis, as well as making analyses of the oil that was mixed with the paint paste by hand. The oil almost invariably was found to contain considerable moisture, as well as a large percentage of mucilaginous or albuminous matter, which is commonly called "foots." Portions of the "foots" from the various samples of oil collected were placed upon sterile agar, and in a few days marked growths of pink colored mould were obtained, identified later as a specie of *Fusarium*. Portions of this mould placed upon oil seemed to produce free acid, which explains the washing of paint in which the

infected oil was used. The enzymes and micro-organisms in the "foots" apparently exerted a fat-splitting action, the oil being broken up into glycerine and fatty acids, causing the formation of soap-like products which are acted upon by moisture, in addition to which the glycerine formed in the film serves to keep the paint soft and tacky, readily attracting moisture from the air. The moisture in its turn emulsifies with the soft paint, some of which washes off.

The washing of paint is not of uniform occurrence. It may be noticed upon the porch columns, but not in the body or trim of a house, and only upon certain sections of the main structure. The writer has observed that in most instances where washing has shown itself, it has generally been on a hollow column or a surface the back of which may hold moisture. It is likely that the moisture stored up in certain places is responsible for starting this reaction.

The so-called "rust" or brown spotting of paints may be traced, in some cases, to the action of soluble matter contained in the wood exuding at certain places in the paint film and drying up into small, hard globules. It may also be due to the nature of the oil if it contains moisture and "foots" of an infected nature. In such cases, the hydrolizing action of the enzymes apparently increases the tendency of the oil to break up into various fatty acids, including formic acid. This has a solvent effect upon the lead and zinc pigments, producing lead and zinc formates which are soluble in water.

From the above, it is apparent that the selection of a satisfactory oil is of very important consideration, especially upon repainting work. Immunization of oils is best done by the application of heat, which is not, however, directly feasible in some cases. On the other hand, mixtures of oil and pigments are often run through Buhrstone mills at temperatures up to 240 deg. fahr. (depending upon the rate of grinding and set of plates), which is more than sufficient for sterilization.

Tests by the author have shown that paint is in a most satisfactory condition after storage if the hot paste was allowed to cool before thinning and canning. When, however, paste paints are thinned by the painter, only clarified, well settled, moisture-free linseed oil should be used (15 pp., 15 fig. *epA*).

## INSTITUTION OF MECHANICAL ENGINEERS

*Advance paper B, read May 14, 1915, London.*

The Distribution of Heat in the Cylinder of a Gas Engine, Professor A. H. Gibson and W. J. Walker

The paper presents data of tests having for their purpose the determination of how the distribution of heat throughout a gas engine varies with the speed of the engine, b.h.p., and the compression ratio, and richness of the air ÷ gas mixture.

Tests were carried out on an experimental gas engine recently installed in the engineering laboratories at University College, Dundee. This engine, with a cylinder diameter of 11 in. and a stroke of 19 in., afforded exceptional facilities for such investigations. The connecting rod could be lengthened so as to vary the compression ratio between the limits of 5.17 and 6.62. The cylinder jackets were divided into two parts, one of which surrounded the exhaust valve and the portion of the exhaust passage included within the cylinder casing, while the other covered the breech end and barrel of the cylinder. The jacket water was led in series through the two sections, the temperature being measured before and after passing through each of these. This made it possible to ascertain, with a higher degree of accuracy than usual. the heat lost to the jacket apart from that portion of it which correctly should be attributed to exhaust losses.

The normal speed of the engine was 200 r.p.m., but in the trials a range of speeds from 140 to 260 r.p.m. was examined. The b.h.p. was varied from zero up to full load capacity. Three different compression ratios and three different air-gas mixtures were used. In all, 130 trials were carried out, the details of which are described in the paper. In the main it was found that:

The *mechanical efficiency* of the engine increased with increase in loads; diminished as the ratio of air to gas increased; diminished as the speed increased and was sensibly independent of the compression ratio; the maximum efficiency attained in these trials at full load with the richest (7:1) mixture, and at the lowest speed (150 r.p.m.) was 88 per cent.

The *thermal efficiency* as measured on i.h.p. increased with the load; attained the maximum with an air-gas mixture of approximately 10 to 1; increased very slightly as the speed increased and increased as the compression ratio increased.

*Thermal efficiency on b.h.p.* increased with the load; attained a maximum with an air-gas ratio of 8 to 1, that is, with a richer mixture than gave maximum i.h.p. efficiency; diminished as the speed increased and increased with the compression ratio.

The *ratio of the actual thermal efficiency* measured on the i.h.p. *to the corresponding air cycle efficiency* increased with the load; had maximum value when the ratio of air to gas was approximately 10 to 1; increased slightly with the speed and was sensibly independent of the compression ratio. At full load and with the most efficient air-gas mixture, the relative efficiencies were for all compressions from 0.687 at 150 r.p.m. to 0.709 at 250 r.p.m.

The percentage *exhaust losses* diminished as the load increased; diminished very slightly as the ratio of air to gas increased; increased as the speed increased and diminished as the compression ratio increased.

*Jacket losses.* The percentage heat carried away by the water flowing through the cylinder jackets, not including the exhaust valve jacket, increased with the load; diminished as the speed increased and was sensibly independent of the compression ratio. Various facts indicated that the rate of transmission of heat through cooling surfaces was much greater at the higher speed in spite of a lower gas temperature. This was apparently due to the fact that the greater turbulency of the working fluid at the higher rates of speed increased its effective conductivity to an extent which more than counterbalances the effects of a smaller temperature difference and a shortened time of contact. Other things being equal, a 6 per cent increase in the temperature of the gases would probably increase the heat transmitted by conduction and radiation by some 15 per cent, so that it might be taken approximately that the effective conductivity was increased in the same ratio as the speed of the engine.

The *radiation loss* diminished as the load increased; increased as the ratio of air to gas increased; diminished as the speed increased and increased slighly as the compression ratio increased. (23 pp., 6 figs. *e.*)

## INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

*No. 55, London.*

### Telegraph Traffic and Power Plant for Pneumatic Tubes in Post Offices, Alec B. Eason

The information in the paper was collected in order to form estimates of the cost of pneumatic installations and current for working various tubes. The problem of determining the probable traffic which the tube will carry under certain conditions, and especially the hourly maximum carrying traffic, is discussed. From this, the writer proceeds to the question of the quantity of air which will be needed to drive the carriers through the proposed tubes; and finally, the size, type and kind of pump which will be most efficient for the work and the probable over-all efficiency of the motor and pump. Only electrically driven sets are considered, these being, in the estimation of the author, the type used almost exclusively in modern installations wherever possible. Only the second and third sections of the paper (Air Required in Installations, and Pumps and Motors), are abstracted here.

In regard to air used per carrier in street tubes, the writer points out that when sending with pressure, the amount of air used for any practical container pressure may vary greatly, according to the types of cocks which are used and the amount of throttling in the circuits. The author describes a series of tests made to determine the amount of air and gives the following formula for the quantity of air used in tubes working intermittently:

$$Q = \frac{V}{13.08} \; \frac{p' - p''}{14.7}$$

where $Q$ = pounds of air; $V$ = the container volume in cubic feet; 13.08 = cu. ft. of air in 1 lb. at 60 deg. fahr.; and $p' - p''$ = drop in the container pressure in pounds per square inch, the temperature of the container being assumed to be constant during the time of the test.

In regard to vacuum working, it appears that with the same vacuum in the container, approximately the same amount of air, 7 lb., is used no matter what the throttling may be. The practical importance of this fact is that with intermittently worked tubes, used in an upward direction, one can introduce full bore services and get increased speed without increased consumption of air. The usual objection as to lax attendance applies to any kind of service, and although increased loss may occur when working with full bore cock, at increased speed, the amount of the increase is small and may easily be overbalanced by saving in the loss due to leakage in the three-way cocks, as the author shows by a calculation.

As regards working with different container pressures, it has been found that with a 5 lb. container pressure and full bore cock, the total time is 55 seconds as against a transit time of 53 seconds when using a container pressure of 8 lb. and the cock at half position; the consumption of air at the lower container pressure was five-sixths of that at 8 lb. pressure. It is best, therefore, to get rid of throttling and use lower container pressures.

Tests at Hull, made in 1911, have shown that the increased speed with high vacuum was obtained without any increase in air consumption, but it should be noted that the energy consumption is increased because the air is taken to a higher vacuum.

A series of tests were made on house tubes, i.e., those which lay wholly within one building. The author found that for house tube work, it would be necessary to allow a consumption of air of from $1\frac{1}{4}$ to twice the volume of the tube. If the speed is high, the consumption will rise to 2 or $2\frac{1}{2}$ times the volume of the tube. The loss due to differences in turning off the cocks promptly is relatively great, as the transit time of carriers is only 5 to 10 seconds.

The leakage of pneumatic tube systems may be divided into three kinds: *a* leakage from the container, pipe-work, and cocks; *b* leakage from the D boxes, double slide switches and fittings, and *c* leakage from the tubes. Leakage *a* occurs in the building, is easily noticeable and therefore should not exist to any great extent. Leakage *b* always exists, but varies in extent with the age and wear of the sliding portion of the fittings. Leakage *c* should not be allowed to any great extent, but it is difficult to locate the position of the leaks in street tubes and repairs to them are costly. Leaks are sometimes allowed to continue, therefore, as long as they do not affect the working of the tube too much. Leakage *a*, at Brighton, amounted to about 68 lb. of air per day, the total amount being 300 lb. The leakage at Hull, on a vacuum container, caused a rise of 2 lb. in $3\frac{1}{2}$ minutes, equivalent to about one-fifth of a pound per minute extra work. For leakage *c*, on London tubes the following amounts (including leakage *b* in some cases) were found: For individual tubes, .22, .30, .47, .37, .60, 5.4 lb. of air per minute. The total leakage for nine tubes working on pressure was 4.7 lb. and for twenty tubes worked on vacuum, 3.5 lb. The total *b* and *c* leakage in London is about 900 lb. per hour, or something like 5 per cent of the total load.

The author considers in detail the various types and dimensions of carriers, and comes to the conclusion that carriers should fulfill four requirements: *First,* large capacity; *second,* retentivity, which means that messages should not drop out of them; *third,* durability, and *fourth,* ease of manufacture. Metal carriers, to be satisfactory, must have buffers or felt skirts at both ends.

The author likewise discusses the various systems of working pneumatic tubes, such as the Dudley system installed when the tubes are short enough, and the high pressure system, with which a saving occurred when the ratio of the maximum load to the average was large. Tests with high pressure systems have shown that it was not worth while pumping air to high pressures. The usual limits were from 10 to 50 lb. per sq. in. and the investigation showed that the higher the pressure, the greater the total energy consumption, including the light load loss, for the whole day.

A careful investigation was made to determine the size of pumps required to deal with air under various conditions of pressure and vacuum as well as the size of motors needed to drive these pumps. The author derives a formula showing the rising pressure in the time $t$, when the speed of the pump is supposed to be constant. He also discusses the question of volumetric efficiency of the pump. The results of the tests at Hull, Brighton and Sheffield show discrepancies when compared with the usual theory. In general, the author arrives at the following conclusions:

The input to motors driving air compressors is 1.6 to two

times the work required to compress the amount of air dealt with isothermally between the working pressures (from tests, it has been found that working with pressure accurate figures for either volumetric efficiency or over-all efficiency cannot be obtained by noting the rise of pressure in closed containers). The maximum horse power input to motors driving vacuum pumps delivering it to the atmosphere, is 1/25 of the displacement in cubic feet per minute. (104 pp., 11 figs. *eA.*)

## ROYAL SOCIETY

*Proceedings, Series A, vol. 91, no. A 628, April 1, 1915, London*

On Thermophones, P. de Lange.
A Bolometric Method of Determining the Efficiencies of Radiating Bodies, William H. Bone, H. L. Callendar, H. James Yates.
The Elastic Properties of Steel at Moderately High Temperatures, F. E. Rowett (abstracted).

### The Elastic Properties of Steel at Moderately High Temperatures, F. R. Rowett

In a previous paper the author gave results of measurements of elastic hysteresis of steel tubes when subjected, at ordinary room temperature, to torsional stresses within what is ordinarily regarded as the elastic limit. In the present research, an attempt was made to establish the difference in the behavior under stresses at higher temperatures of both hard-drawn tubes and annealed tubes.

It was expected that the former, containing a good deal of amorphous material, would begin to behave like a viscous fluid,—that is, it would flow, more or less freely, under stress, whereas at the same temperature, the annealed tube being crystalline, though it might take a permanent set, could not flow or would flow to a much lesser degree, on account of the small amount of amorphous material in it.

It was found, actually, that at a temperature of 300 deg. cent., hard and annealed tubes began to show properties similar to those of pitch at ordinary temperature, or of glass at a temperature rather below the softening point. They were still highly elastic under varying stresses, but flowed perceptibly when the stress was applied for a great length of time, the energy dissipated in a cycle of stress depending upon the speed of the cycle. If the cycle was performed in five seconds, the area of the closed stress-strain loop was not much greater than at ordinary temperature and was less than that given by an annealed tube, but if the cycle took a quarter of an hour, the dissipation was increased four-fold.

In the annealed tube, however, at 300 deg. cent., the energy lost per cycle of stress was still almost independent of the time. At a higher temperature—for example, at 540 deg. cent.—the hard drawn tube flowed rapidly and continued to flow for a long period, though at a diminishing rate under a shear stress of less than one ton per square inch. At this temperature, steel, like pitch or glass, showed considerable after-working. Some flow and elastic after-working were also observed in the annealed tube at this temperature, but both of these tendencies were much less than in the hard.

The steel tubes had the following chemical composition: Carbon, 0.17 per cent; manganese, 0.24 per cent; sulphur, 0.02 per cent; phosphorus, a trace.

The elastic limit in torsion of the tubes as supplied by the makers was 13.8 tons per sq. in. shear stress in either direction, giving an elastic range of 27.6 tons per sq. in.

The data of tests are presented in the original article in the form of tables and curves. (13 pp. 4 figs.)

## ROYAL SOCIETY OF ARTS

*Journal, vol. 63, Nos. 3259 and 3260, May 7 and 14, 1915, London*

(No. 3259) On the Measurement of the Efficiency of Domestic Fires, and on a Simple and Smokeless Grate, A. V. Harcourt (abstracted)
(No. 3260) Recent Progress in Pyrometry, Chas. R. Darling

### On the Measurement of the Efficiency of Domestic Fires, and on a Simple and Smokeless Grate, A. V. Harcourt

The writing of the present paper was prompted by a desire to determine whether a sprinkling of a solution of a powder in water, consisting mainly of common salt, on lump coal, burned on a domestic grate, increases the efficiency of the fire. Theoretically, this did not seem likely, but the

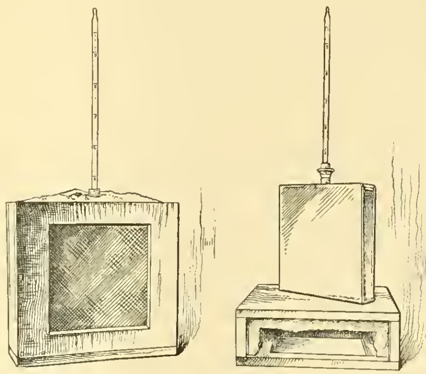


Fig. 7 "Radio" Thermometer for Measuring Radiant Heat

writer wanted to establish definitely what actually would happen.

To do this, he found it necessary to measure the amount of heat radiated into a room, which led to the development of the instrument illustrated in Fig. 7, which the author calls a radio-thermometer, i. e., a measurer of radiant heat. It consists of a copper box 6 x 6 x 1 in., with a small funnel-shaped inlet, enclosed in a wooden box 7 x 7 x 2 in., open at the top and with an opening 5 in. square in the middle of one side. Except on this side, there is a space between the two boxes, of an inch at the back and ½ in. at the sides and below, loosely packed with cotton-wool. On the side which is in contact with the wood, the central 25 sq. in. are exposed and blackened. A thermometer, used also as a stirrer, is held by a cork in the opening at the top. It is furnished with a cup-shaped piece of sheet rubber tied on above the bulb, stretching across the box. The weight of the copper box is 11 oz.; that of the water which fills it, is 1 lb. 6 oz. The water-equivalent of the copper box is $11 \times 0.095 = 1.045$ oz.; hence the mass of water heated may be taken as 1 lb. 7.04 oz., or 1.44 lb.

The instrument having been freshly filled with cold water is placed facing the middle of the fire at a distance of 3 ft. Exactly on the minute by the watch, the thermometer is

read; about 9 min. later the water is briskly stirred up and down with the thermometer, which is then replaced with its bulb central, and at the end of 10 minutes, the thermometer is again read. These readings are repeated every 10 minutes until the temperature of the water is as much above the temperature of the air taken by a thermometer at the back of the instrument as it was below it at the start. The cotton-wool, which checks the flow of air around the box, prevents the temperature of the air in the room having too much influence, and both this and the exchange of radiation are approximately balanced by the temperature of the water, being to an equal extent and for nearly the same time, first lower and then higher than that of its surroundings.

To make the results, with the fire larger and smaller at different times, more nearly comparable, an estimate was made every ten minutes of the area of fire, from which the chief part of the heat was being radiated (this area is expressed in "spaces"). A large number of measurements have been made of heat radiated from coal, from coke, from coke which had been wetted and from coal and coke treated with a salt solution. The average results in units of the method are as follows: coke, 1.97; coal, 1.63; wet coke, 1.29; coke and coal sprinkled with water and powder, 2.03 (the presence or absence of the powder made no practical difference).

These results seemed to be probable. Coal, when it burns, passes through two distinct stages; first, it gives off gas, some of which is burned and some of which escapes unburned. When evolution of gas has ceased, the coal has been changed to coke and the second stage begins, when it burns with a steady glow. During the first stage, much less heat is radiated than during the second, as the heat from the burning gases goes chiefly up the chimney. Wet coke, if sufficiently wet, gives still less heat at any moment, for it burns more slowly and some of its heat goes to evaporate the water.

From this, the author proceeds to the description of a special grate for use in domestic fires. He establishes a number of principles which should be observed in the construction of a domestic fire grate and points out that in addition to purely technical requirements, the grate must not be less attractive in appearance than other grates. He shows, however, several quite attractive illustrations of his design. (9 pp., 7 figs. *gpd.*)

## WESTERN CANADA RAILWAY CLUB

*Proceedings, vol. 7, no. 8, March 1915, Winnipeg.*

### The Handling of Fuel Oil in Extreme Climatic Conditions, Lorimer.

The paper discusses the use of oil fuel generally, and in very cold regions in particular, and described the design of special tank cars and storage tanks.

The ordinary tank car is usually of too small a capacity, say 8,000 U. S. gal., which means transportation of a comparatively heavy dead load for a small quantity of fuel. Also its design is not convenient; for example, it has the valve located about 2 ft. off the center line, hence, in making up the train, the cars have to all be headed the same way, which, in railway practice, is almost impossible. Then it has a small opening in the dome which is generally closed by a round cover provided with a thread, a very objectionable arrangement, especially in very cold weather. Such tank cars are not provided with steam heating pipes and, with an outlet of only 4 in. exposed to the cold weather, it takes a long time to empty the car and, further, it is almost impossible to empty it completely because of the bottom of the car being level. As much as several hundred gallons may remain in the car, and thus not only reduce its effective capacity but remain to be carried back and forth on the line.

To obviate all these objections, a new tank car has been designed with a capacity of 10,000 Imperial gal. It has a dome provided with an opening of 18 in. x 36 in., the cover being hinged and hermetically sealed by means of eye bolts and hand nuts (this makes opening easy in any kind of weather). To make the spotting of the car easy, it has been provided with an outlet valve exactly in the center, and the steam inlets for heating the car are also placed exactly on center, one on each side of the car, so that the car can be headed either way. For purposes of heating, the car is provided with the piping so arranged that the steam starting from the center will travel at once toward the two ends and then come back to the center around the outlet valve which is in its turn provided with a steam jacket, the water of condensation being discharged through a Sarco valve of ample capacity.

For rapidly and completely emptying the car tank, there is provided a trough running longitudinally between the bolsters. This trough is 8 in. wide and riveted to the bottom of the tank is a semi-cylindrical bottom with a depth of 6 in. at the outside extremity and 1 ft. in the center. The outlet valve is riveted to this trough. Six 6 in. and one 6 in. x 18 in. hole in the center let the oil run through the whole length of the car into the trough. The return steam pipe is placed in the bottom of this trough and is connected to the steam jacket of the outlet valve. This permits the oil to be heated thoroughly and run quickly, while the 6 in. fall of the trough towards the outlet valve allows the car to be completely emptied.

The body of the car is composed of a center sill and two body bolsters, resting on the trucks. The center sill, 37 ft. 3 in. in length over striking plates, or 39 ft. c. to c. of couplings, is made of two 12 in. 40 lb. ship-building channels (Carnegie Section) spaced 12⅞ in. back to back. The two ends up to the bolsters are covered top and bottom by ½-in. cover plates, and between the bolsters, the bottom flanges of the channels are strongly latticed together, and the top flanges are reinforced by two 8 x 3½ x ½ in. angles.

The saving of weight due to this kind of design is about 3,500 lb. per car, the approximate weight of an ordinary tank car of the same capacity being about 44,000 lb. (24 pp., *gpd.*)

## CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

# MEETINGS

## WORCESTER, APRIL 8

At a meeting of the Worcester Section of the Society on April 8, the following committee was appointed: Paul B. Morgan, chairman; Carl F. Dietz, H. P. Fairfield, F. W. Parks and E. H. Reed, secretary.

## ST. LOUIS, MAY 19

A meeting of the St. Louis Section was held at Washington University on May 19 and was presided over by Mr. J. W. Woermann, President of the St. Louis Engineers' Club. There was no single paper as such, but a general discussion took place covering the requirements and length of an engineering course of study. Professors A. S. Langsdorf, J. L. Van Ornum, E. L. Ohle, G. O. James, of Washington University; and Professor E. L. McCausland, of the University of Missouri, led the discussion. After the discussion, inspection of the laboratory at Washington University was made.

## CINCINNATI, MAY 20

At a joint meeting of the Cincinnati Section of the Am.Soc.M.E. and the Engineers' Club of Cincinnati on May 20, Dr. A. O. Zwick gave an illustrated lecture on Egypt, Light of the World, which showed how our modern civilization is based upon the works of the Egyptians. They originated many of the present-day professions, and their knowledge of many branches of science was more highly developed than was found in our civilization 150 years ago. Dr. Zwick also showed how to compute the ages of the great Egyptian monuments and other structures that were erected some 13,000 years ago. Through the key to the Egyptian language (the Rosetta stone), found by an engineer, many valuable works have been translated which reveal that a remarkably high degree of development in culture and science existed in that remote period.

## ST. LOUIS, JUNE 9

A joint meeting at the St. Louis Engineers' Club rooms, presided over by Mr. J. T. Garrett, Vice-Chairman of the local section of the American Society of Engineering Contractors, was held on June 9. The paper of the evening was by J. B. Emerson, of the Robert W. Hunt & Company, on "Needed Improvements in Specifications." The main points brought out were: *First,* too many specifications, while calling for specific tests, do not state with what frequency such tests should be applied; in other words, the number of tests per unit, or number of units per test, being entirely omitted. *Second,* the general clause of many specifications conflict with details given later, leading to much ambiguity. *Third,* the working limits of dimensions given should be more clearly defined. A specification without such limits, in the hands of an inexperienced inspector, causes the contractor a great loss, calling for minute measurements which are neither required nor desirable in that class of work. This paper was discussed by H. M. Cryder, Mr. Cramer, and others.

This was followed by an outline of tests being made by the United States Bureau of Standards, on full sized columns, by Dr. R. G. Olhausen. The total attendance was 46.

## MINNESOTA, JUNE 11 AND 12

A joint meeting of the Minnesota Section with the Minnesota Section of the A.I.E.E. was held on June 11 and 12 in Duluth. Mr. Ryerson of the Great Northern Power Company gave a paper, illustrated by lantern slides, on the Great Northern's development and business. Mr. Hearding of the Oliver Iron Mining Company gave a moving picture talk on the Iron Ore Industry of Minnesota. The pictures showed all the process in the mining, from the prospecting to the loading of the ore on the boats for shipment.

The second day of the meeting was taken up with excursions, which included various docks and the new plant of the Minnesota Steel Company.

## LOS ANGELES, JUNE 15

A joint meeting of the technical societies in Los Angeles was held on June 15. William Mulholland, chief engineer of the Los Angeles water board; James A. B. Sherer, president of Throop College of Technology, and Samuel Storrow, addressed the meeting on The Service of the Technical Man to the Community.

## ST. LOUIS, JUNE 16

A joint meeting under the auspices of the A.S.M.E. was held on June 16, at which Edward Flad, Chairman of the local branch of the A.S.M.E., presided. The paper of the evening was by E. R. Fish, secretary of the Heine Boiler Works. His paper was entitled: Boiler Explosions, and What the A.S.M.E. is Doing to Prevent Them. He traced the development of the idea of standard specifications; how the requirements for safety in boilers were first put into concrete form by Thurston; showed how closely the A.S.M.E. Code fulfilled Thurston's outline requirements. He then told of the lack of uniformity of boiler codes among the various states, and the efforts being made by American Boiler Manufacturers Associations to obtain the adoption of the new code, by all of the state legislatures.

The lecture was concluded with illustrations showing boiler explosions and bad conditions due to failure to follow best engineering practice, both in design and operation of boilers.

There was an interesting discussion following the presentation of the paper by Edward Flad, Prof. E. L. Ohle, L. A. Day, Wm. Hoffman, and others.

At the same meeting the report of the joint committee was made, on the proposed water power development through diverting water from the Missouri to the Meramec Rivers. Previously the Missouri State Legislature had reported on this project favorably, estimating a probable development of 200,000 hp. The Engineers' Club report was distinctly unfavorable, showing that the possible horse-power was only 37,000, and the cost of development much more than that estimated by the state legislature.

# NECROLOGY

### EBENEZER HILL

Ebenezer Hill was born in South Norwalk, Conn., on October 5, 1849. He graduated from Wesleyan University with a degree of B.A. in 1870, and with a degree of M.A. in 1891. From 1870 to 1880 he was engaged, in connection

with others, in the design, construction and installation of steam pumping machinery and steam engines of various types. In 1880, he became the responsible executive head of the Norwalk Iron Works Company, and shaped the business to the manufacture of air compressors and allied machines. He held this position up to the time of his death, which occurred on February 26, 1915.

### JOHN PHILIP ZIPF

John Philip Zipf, Jr., was born at West Point, Cal., on March 19, 1888. He attended the California School of Mechanical Arts and the University of California, from which he graduated in May, 1912. After graduation, he worked with Mr. R. F. Chevalier, a consulting engineer, in testing boilers for numerous gas and power plants in and about San Francisco. In December, 1912, he accepted a position with the Ramie Fibre Company of San Francisco as draftsman. After the failure of this company, he accepted a position with the Sutter Basin Company of Sacramento as draftsman of plans for electric pumping machinery for their reclamation project. Having completed their work in May, 1914, he entered the office of the California State Engineer at Sacramento, Cal. Mr. Zipf died at his home in San Francisco, Cal., on May 24, 1915.

### BENJAMIN FRANKLIN ISHERWOOD

Benjamin Franklin Isherwood was born in New York on October 6, 1822. He was educated at Albany Academy and afterward served under David Matthews, master mechanic of the Utica and Schenectady Railroad. He was promoted to the civil engineer's office and, on the completion of the road, he went to work on the Croton aqueduct. After this was completed, he worked on the construction of the Erie Railroad under Charles B. Stuart, division engineer, who later became engineer in chief in the navy, and it was through his influence that Mr. Isherwood entered the navy in 1844. Later he was assigned by the U. S. Treasury Department to work on the construction of light houses, and was sent to France to superintend the construction of light house lenses there from his own designs. At the outbreak of the war with Mexico, he served on board the Princeton, the first American screw steam vessel built by Ericsson for the government as an experiment. He was promoted to be chief engineer of the Spitfire, and he took part in every action in which the American fleet was engaged during the war.

His experiments in the expansion of steam on board the U. S. S. Michigan in 1859 almost revolutionized the methods of using steam. He designed the engine of the U. S. cruiser Wampanoag, which was built in 1868 and which was the fastest steamship in the world at that time. She had a speed of seventeen and three fourths knots.

He was chief engineer in the navy from 1861 to 1869, covering the entire period of the Civil War, when more than six hundred steam vessels and three thousand engineers were in the service.

During the years 1870 and 1871, he was stationed at the Mare Island Navy Yard, California. His experiments there with screw propellers are regarded as among the greatest additions to engineering. He was retired as chief engineer with the rank of rear admiral on June 6, 1884. He was the author of many engineering works, some of which have been used widely as text books in technical schools.

Mr. Isherwood died at his home in New York City on June 19, 1915.

## PERSONALS

Thomas R. Cook, until recently assistant engineer of motive power, Pennsylvania Lines West, Pittsburgh, Pa., has accepted the position of chief engineer of the Willard Storage Battery Company, Cleveland, Ohio.

Everett W. Swartwout, formerly of the Chicago office of the Nordberg Manufacturing Company of Milwaukee, is now associated with M. N. MacLaren in the New York office of the company.

John E. Lord has accepted a position with the Nordberg Manufacturing Company as manager of their Chicago office. He was until recently with the Buckeye Engine Company.

Myron J. Bigelow, who was connected with the Molyneux Mailing Machines Company of Buffalo, N. Y., has severed his connection with that company and is now consulting engineer, located temporarily in Akron, Ohio.

Gustave R. Tuska, consulting engineer, New York, has been appointed lecturer in municipal waste disposal at Columbia University, New York, and will deliver a course of lectures on this subject at the University during the coming year. Mr. Tuska has for some years been acting as consulting engineer to various garbage, refuse and waste disposal plants both in this country and abroad.

Ronald C. Hands has become affiliated with the Winchester Repeating Arms Company, New Haven, Conn., as assistant to the supervisor of the mechanical division. He was, until recently, connected with the planning and efficiency work of The Bridgeport Brass Company, Bridgeport, Conn.

David J. Lewis, Jr., has become associated with W. J. Wayte, a chemical engineer, with offices in New York, operating as consulting engineers under the title of W. J. Wayte, Incorporated. Their specialty is the utilization of wastes in power and manufacturing plants, especially in sugar and chemical works.

T. Omdal, formerly mechanical engineer with Lieberman and Sanford Company, New York, is now a member of the firm of The Equity Iron Works, Brooklyn, N. Y.

William E. Choate, acting general manager of the Carr Fastener Company, Cambridge, Mass., will leave that position August 1 to take a similar one with The Advance Machine Company of Boston, Mass.

John E. MacArthur, formerly connected with the Pierce-Arrow Motor Car Company and more recently superintendent of the Keystone Manufacturing Company, resigned on May 1 to become general superintendent of the Robinson Fire Apparatus Manufacturing Company of St. Louis, Mo.

Jacob M. Howarth has become associated with Marshall Field and Company of Chicago, Ill., as assistant chief engineer. He was until recently mechanical draftsman and test engineer in the U. S. Yards of Swift and Company, Chicago, Ill.

Harold K. Beach has been transferred from the Atlanta, Ga., office to the New York office of Lockwood, Greene and Company.

William E. Bullock has resigned his position as assistant to the Secretary of The Franklin Institute and has been appointed on the editorial staff of the Am.Soc.M.E.

George B. Massey has resigned as foreign sales manager of the Bucyrus Company and has formed the Geo. B. Massey Company, consulting engineers, on excavating machinery and methods, with offices in the Peoples Gas Building, Chicago.

Edwin G. Hatch has opened an office for consulting work in the Equitable Building, New York, and will have associated with him Herschel C. Parker, for twenty-one years professor of Physics in Columbia University. Mr. Hatch was formerly associated with Walter G. Clark of New York, specializing in electrical work, having entire charge of the work in New York since 1913, during Mr. Clark's absence in the West. Mr. Hatch was also treasurer and manager of the Clark Electric Company, and was largely instrumental in developing the company's high tension line apparatus.

## STUDENT BRANCHES

### CARNEGIE INSTITUTE OF TECHNOLOGY

The last meeting of the year held by the Carnegie Institute of Technology was addressed by George H. Redding, assistant secretary of the Institute, on The Success of Mechanical Engineering Graduates of the Carnegie Institute of Technology.

Mr. Redding first told of the method used for keeping statistics of the graduates. Every year a blank is sent to each graduate to be filled out and returned to the Institute. The information asked for included the kind of work being done, the salary being received, and whether the man is satisfied with his work. He is also asked in what range his salary lies. In reply to the last question, the following ranges have been submitted: 900-1200, 1200-1500, 1500-1800, 1800-2000, 2000-2500, and above 2500. This method has proved quite satisfactory, and most of the graduates have responded with the required information. Mr. Redding said that, however unfair it might be to measure a

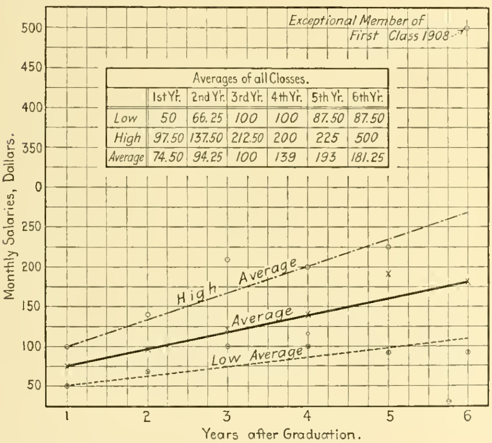



FIG. 1 CURVES OF SALARIES OF GRADUATES IN MECHANICAL ENGINEERING OF THE CARNEGIE INSTITUTE OF TECHNOLOGY, SCHOOL OF APPLIED SCIENCE

man's success by the salary which he receives, it is their only means of tabulating and representing in graphical form the progress of a large number of men over a period of years, and that the accompanying chart would give young engineers a fair idea of what they might expect when they got out into the world of working men. The data which has been used has included information from approximately ninety per cent of the mechanical engineering graduates. Some men just out of college become, in a short time, dissatisfied with the routine and grind which must always be undergone if success is to come. It is a significant fact, however, that the majority of these mechanical engineers who deviated from engineering work eventually went back to the field for which they were trained. One man, for instance, a graduate of early years, went into another field of work in which he was able to make a very large salary. He is now, however, doing mechanical engineering work whereby he can gain additional experience, and, although his salary is small, he says that he is satisfied.

### COLORADO AGRICULTURAL COLLEGE

At a meeting of the Colorado Agricultural College Student Branch on May 29, Professor Crain addressed the society on the uniflow engine. He described first the heat loss that takes place in the counterflow engine, due to the condensation, and how the loss is minimized by the uniflow principle. He then described the Stumpf Uniflow Engine which has been developed in Germany. The Stumpf engines are run condensing, and, in order to meet the American requirement of running non-condensing, an auxiliary valve has been added. By means of diagrams, he illustrated the difference between the valves of the counterflow and those of the uniflow engines.

### KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College on June 9, the following officers were elected for the coming year: L. A. Wilsey, president J. I. Michaels, vice-president; F. R. Rawson, secretary, and Charles Zimmerman, treasurer.

W. L. Rhoades, a senior in the mechanical engineering course, gave a paper on Variable Compression on the Economy of a Corliss Engine, which were the results of a thesis which was carried on by him and A. H. Ganshird on the economy of a simple, non-condensing Corliss engine. They gave as the results of their tests that as the compression increased up to about eighty per cent of the initial steam pressure, the economy of the engine increased. From the results of Clayton's analysis, the conclusion was made that there was leakage past the piston of the engine used in the test.

Shelby Fell, a senior in the course of electrical engineering, gave a paper on Tests of a Mercury Arc Rectifier, which were the results of his thesis which was performed to determine the efficiency, shape of the wave and losses of a mercury arc rectifier.

### PENNSYLVANIA STATE COLLEGE

A meeting of the Pennsylvania State College Student Branch was held on May 19. W. D. Garman, president of the Branch, read a paper on Student Branches of the A.S.M.E. issued by the Society.

The following officers were elected for the coming year: H. L. Mummert, president; G. H. Dunn, vice-president; E. J. Kenney, secretary; P. N. Ziegler, treasurer, and Prof. J. P. Calderwood, of the Advisory Committee, to countersign checks.

### PURDUE UNIVERSITY

A meeting of the Purdue University Student Branch was held on May 18, at which the following officers for the coming year were elected: W. F. Miller, chairman; R. B. Stein, vice-chairman; H. R. Snyder, recording secretary; L. C. McAuley, corresponding secretary, and O. F. Hambrock, treasurer.

C. T. Sprado, chief designing engineer with the Allis-Chalmers Manufacturing Company of Milwaukee, spoke on Gas Engine Practice. His discussion was mainly on the internal combustion oil engine, the study of which he has spent some twelve years. The oil engine that was described was the one made by the Allis-Chalmers Company. Illustrative slides were used, showing each part of the engine in detail. The engine is of very late development, very similar to the

gas or gasoline engine in construction. A horse-power, however, can be developed at a much lower figure than by either of the other engines. Each part of the engine was taken up and explained in detail, the first part discussed, being the different types of plungers used and the one that has proved most satisfactory. In discussing the different types of valves, Mr. Sprado made the statement that the valve being used at present on the piston is almost perfect in design. It has been tested in their shops, and has been in use on engines that run continuously twenty-four hours a day for six months without stop. The Allis-Chalmers engine has many improvements in the working of the piston which makes it distinctive above all other types.

Mr. Sprado also made a comparison of the vertical and horizontal types of engines. He disproved the idea that most people seem to have that the horizontal engine takes more floor space than the vertical. He showed that the lubrication of a horizontal engine was more thorough and the system much simpler. A vertical engine is not guaranteed to be started in less than five minutes and it is a considerable job. The horizontal engine made by the Allis-Chalmers people may be started in less than one minute. Following this, a few slides were thrown on the screen, showing efficiency curves of the different types of engines.

### SYRACUSE UNIVERSITY

A meeting of the Syracuse University Student Branch was held on May 21, at which the following officers for the coming year were elected: D. R. Hay, president; S. S. Amdursky, vice-president; H. B. Tracy, secretary, and E. H. Brooks, treasurer.

Dr. John E. Sweet gave a lecture on Harmony of Theory and Practice, and gave many examples where theory and practice do not harmonize. Principles worked out by scientists very many times cannot be adopted in engineering projects. The impression left with the audience was that an engineer's experience is worth much more to him than his technical training, but that he must have both to be successful, and that he must not place too much faith in pure science, but realize that he must separate by his accumulated knowledge the practical from the impractical.

### THROOP COLLEGE OF TECHNOLOGY

At the regular meeting of the Throop College of Technology Student Branch, held on May 19, Harold Doolittle, assistant construction engineer of the Southern California Edison Company of Los Angeles, told about the construction and the operation of their plant at Long Beach. Most of the students had been to see this plant on an inspection trip a few weeks before this, so that the illustrations and descriptions given by Mr. Doolittle helped to make many of the things clear. This plant, supplying power to a large number of towns and cities of Los Angeles County, has three Curtis turbines, 12,000, 15,000 and 20,000 kva., with sufficient building space for the addition of a fourth unit.

On May 21, a meeting was held at which the following officers were chosen: V. E. Farmer, chairman; C. H. Ridenour, vice-chairman; J. A. Beattie, secretary, and Arthur Stert, treasurer.

### UNIVERSITY OF CINCINNATI

The largest meeting of the school year of the University of Cincinnati Student Branch was held on May 21, at which the following officers were chosen: A. J. Langhammer, president; R. S. Rickwood, vice-president, and W. T. Cowell, secretary and treasurer. The speaker of the evening was A. M. Sosa, chief draftsman of the American Tool Works Company. His subject was Pitfalls Along the Path of the Young Engineer. The speaker pointed out that engineers after graduation separate very quickly, and that each individual had the same set of tools, so to speak, at his command. Now, if never before, the graduate will ask himself the questions: "What is my value? What have I learned and what have I yet to learn?" If an employer were to answer these questions, he would say: "You are praiseworthy, but you lack experience."

During his course the student has learned many things. He has studied physics, mathematics, mechanism, etc., and he has been taught to handle instruments skillfully. However, when a student assumes a position, his work is along one branch of the subject he has studied. He may find that this particular branch has been given but little time in his course. His efforts from now on are concentrated upon this one branch and its details; and as he progresses in his work his knowledge of the science of engineering increases and he gains his experience. The young engineer now realizes that by experience is meant the history of that particular branch of engineering which he is following.

Mr. Sosa emphasized that engineering work is primarily analytic, and if one error is made in the analysis the mistake will show. All engineering knowledge is the result of three things—observation, comparison and combination, and to get results, it is not necessary to know the precise nature of certain phenomena; for example, heat, electricity, friction, etc. We know that, under certain conditions, each will exhibit certain characteristics, and to a man on the job this is quite enough. When new fields are being explored, the methods are analogous; that is, certain facts are discovered, laws are formulated, and results are derived from these.

Professors A. L. Jenkins and A. C. Joerger gave short addresses.

### UNIVERSITY OF MINNESOTA

A regular meeting of the University of Minnesota Student Branch was held on May 6, to which the whole sophomore mechanical engineering class was invited. Professors Martenis, Shoop and Rowley, and Mr. Colvin, of the Post-seniors, spoke on the general theme of membership.

The meeting held on May 13 was open to the whole engineering college, at which H. S. Whiton, of the Minneapolis General Electric Company, spoke on System Operation. He very interestingly described the problems and woes of the operator of a large light and power distribution system like that in the city of Minneapolis. The slides which he used to illustrate his lecture showed the power plants and branch station of the Minneapolis General Electric Company.

The last regular meeting of the Branch was held on May 20. The meeting was called to order to give Mr. Shoop, of the Experimental Engineering Department, a chance to speak to the senior and post-senior men about connecting themselves with the national Society as Junior members.

### UNIVERSITY OF NEBRASKA

At a meeting of the University of Nebraska Student Branch on May 4, the following officers were elected: L. L. Westling, chairman; R. B. Saxon, secretary, and W. C. Chapin, treasurer.

### WORCESTER POLYTECHNIC INSTITUTE

At a meeting of the Worcester Polytechnic Institute held on May 21, the following officers were elected: Harold Nutt, chairman; Thomas W. Farnsworth, vice-chairman; John A. C. Warner, secretary, and Everett H. Francis, treasurer.

Following the executive business, abstracts from several senior theses were read. Among them were Investigation and Test of a White Gasoline Motor, by Harrison W. Hosmer and George W. Smith; Heat Treatment of High Speed Steels to Meet the Cutting Requirements of Different Metals, by Ralph C. Nourse and Austin E. Poirier; and Test of the Westinghouse Electric Lighting, Starting and Ignition System, by Clifton P. Howard and Raymond P. Lansing.

This meeting brought to a close the first year of the Worcester Polytechnic Institute Student Branch. The meetings of the year have been well attended, and, by resort to publicity, the open meetings have been well attended by an interested public, and it is believed that the work of the Branch has been of value not only to the Institute, but to the community as well.

## EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

### POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. In sending applications stamps should be enclosed for forwarding.*

0147 Designer on dies for forgings. Location, New York.

0148 Draftsmen wanted for work on small machine parts. Location, New York.

0149 Wanted: A man to analyze and make recommendations for cutting shop costs; must be familiar with the latest shop practice, be able to figure speeds and feeds and make time studies. Work covers foundry, pattern and machine shops and building power house equipment. Give full information in first letter. Name of company confidential. Location, New York State.

0153 Wanted for Pittsburgh territory young mechanical engineer, as engineering salesman for high grade power plant steam apparatus; condensers, jet apparatus, re-cooling plants, water heaters, etc. Some experience in selling preferred. Apply by letter.

0155 Sales manager for Chicago office of manufacturers of power accessories. Desire a man who is well acquainted with the mechanical engineers in Chicago and surrounding territory. Must be well versed in power plant work, industrious and not afraid to work. Apply by letter.

0156 Engineer for inspection of machine parts. Knowledge must cover quality of machine work and parts. Location, New York.

0158 Checkers on detail drawings of Diesel engines. Men of experience in checking drawings, but not necessarily those who have worked at this particular line. Location, New York.

0160 Young graduate in engineering who has had at least two years experience in heating and ventilation. Location, Michigan.

0163 Chemist for works of manufacturing chemist. Location, New Jersey.

0164 Foreman of shop for manufacturing chemist. Location, New Jersey.

0165 Assistant engineer with experience in supervision of power plant and factory design. Chemical plant experience specially desired, though not necessary. Location, New York.

0166 Position of general manager of sales is open to a man of ability and equipment with a large firm manufacturing heavy machinery. Experience in sale of both steam and gas engines essential. Name strictly confidential.

0167 Foreman for plant repair department of Connecticut concern; department is largely general mill repair work; must be able to handle machinists, millwrights, carpenters, blacksmiths, laborers, masons, etc., and should possess the ability to supervise and keep varied work going at the same time.

0168 Mechanical engineer, capable of taking charge of development department of company manufacturing stokers. Man having experience with forced draft stokers preferred. State age and experience, giving full details and salary expected. Apply through Society.

0170 A consulting engineer of New York, with practice in a special field which can be greatly extended, desires to take into partnership an engineer who can invest some money and with qualifications for conducting investigations in the fields of physics and applied mechanics. Apply by letter.

### MEN AVAILABLE

*The published notices of "men available" are made up from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.*

G-170 Member, sales engineer, located in New York, good correspondent and estimator, broad acquaintance in manufacturing, engineering, and expert in field work, and experience in handling successfully well-known accounts in New England and Eastern States, desires to negotiate with manufacturer wishing a reliable representative in New York who will accept the responsibility for the management and results.

G-171 Member, with an unusually thorough experience in manufacture, and with first class record as executive, at present in successful consulting practice in scientific management, and especially successful in developing capable men, desires manufacturing executive position.

G-172 Member, graduate M.E., ten years experience in the operation of power plants, now specializing in selling coal to power plants, understands selling coal on specifications, desires position as fuel engineer with a dealer or producer of coal.

G-173 Graduate M.E., age 25, two years experience in office work and drafting department of a heating and ventilating concern, desires position in the same or along similar line.

G-174 Junior, aged 26, seven years experience embracing machine shop, drafting room, installation, production and estimating, desires position as assistant to executive or consulting engineer. At present employed but is seeking advancement.

G-175 Member, specializing in the installation of scientific management, can take on a limited amount of additional work.

G-176 Member, age 40, with 24 years of broad, practical and theoretical experience in erecting, operating and consulting capacities, also as master mechanic and mechanical superintendent in connection with the manufacture of ma-

chinery and prime movers, and in the maintenance, reconstruction and operation of paper and jute mills, desires position in either power plant or mill work.

G-177 Associate member with 20 years experience covering general office work, advertising, domestic and foreign sales, with knowledge of shop cost and wage systems and a wide general technical knowledge, has had more than four years business experience in fourteen foreign countries; broad acquaintanceship both at home and abroad and could develop foreign sales or promote manufacturing or sales branches abroad, desires to get in touch with growing concern that desires to increase business. Would accept a nominal salary with an agreement for bonus based upon results or a moderate fixed compensation.

G-178 Member, works manager and mechanical engineer, with nine years experience as engineer on water works, electric power station and steam engine work, twelve years experience as manager and designing engineer, manufacturing plant, building gas engines, automobiles, pumps, tractors and excavating machinery and with six years experience with efficiency methods, has managed 1900 men, laid out, built, equipped and organized plants, would like to build and organize new plant, or improve a growing plant.

G-179 Member, Cornell graduate, age 31, married, six years experience in refrigerating engineering and general power plant work, two years experience in teaching, desires position for the coming academic year in mechanical department of a technical school.

G-180 Member, age 46, technical graduate, married, experienced in engineering work with prominent engine builder and as resident engineer and chairman of safety committee of steel works, desires position. Salary, $3000.

G-181 Factory superintendent or foreman, 15 years executive experience, capable of producing results; practical machinist, toolmaker, and thoroughly conversant with modern manufacturing methods, organizing and increasing production.

G-182 Technical graduate, wide experience as railway mechanical engineer, as machinist, motive power draftsman and mechanical engineer desires position along these lines, or one as mechanical inspector, assistant superintendent motive power, or assistant to general manager. Location, immaterial.

G-183 Associate-member, Stevens graduate, age 27, six years gas engine experience in designing, experimental, testing, machine shop work and sales, desires position as assistant to superintendent or other responsibility.

G-184 Engineer with five years experience in steam turbines, power plant and reinforced concrete work desires permanent position. At present employed.

G-185 Young technical graduate, single, desires work in any branch of the engineering profession.

G-186 Member with broad experience of over 20 years as general manager of large plant including foundry machine and metal working shops, also in charge of sales and financial development and practical experience in all departments, desires position along the same lines.

G-187 Associate-member, age 34, graduate M.E., ten years consecutive and successful experience from machine shop to designing engineer; four years experience in design and construction of ordnance equipment of navy department; five years in design of special machinery, hydraulic machinery and in layout of power plants. Has held positions as draftsman and designer and U. S. Junior engineer and as assistant engineer on construction. At present employed but desires to make change.

G-188 Member, technical graduate, 12 years experience in design, operation and maintenance of heat, light and power plants, especially in improvement and supervision of power plant to obtain greater efficiency. At present employed but wishes to connect with firm of engineers or private corporation.

G-189 Member, age 37, technical graduate, two years consulting and betterment work in factories, ten years experience in designing, engineering production and accounting lines in manufacturing steam, gasoline and automobile engines and light and heavy machinery, desires position.

G-190 Junior, 1914 graduate Massachusetts Institute of Technology, desires position with a mill architect of manufacturing concern. Any position offering good experience and a chance for advancement will be considered.

G-191 Young engineer with technical training and two years experience in the design and manufacture of high duty pumping engines, and one year in the construction and maintenance department of large public service corporation in New York, desires position with a future with firm located in the Middle West.

G-192 Junior member, graduate in mechanical engineering, assistant to steam engineer in large manufacturing works, with experience in power plant supervision and boiler room efficiency, and with knowledge of power costs and distribution in manufacturing, desires position as steam engineer.

G-193 Junior member, Columbia graduate, thoroughly experienced in railway, construction and electrical lines, desires position with consulting engineer or contractor, or similar line. At present employed.

G-194 Junior member, graduate M.E., three years varied experience, desires position as laboratory instructor.

G-195 Junior member, Stevens graduate, energetic, resourceful, capable of handling men, eight years experience in engineering with firm manufacturing power plant equipment, also shop and drafting room experience, desires position which does not necessitate traveling. Has specialized in steam engineering.

G-196 Member, in consulting practice, with broad experience in perfecting general organization of manufacturing companies and in efficiency operation of plants, including familiarity with various processes of manufacture, particularly metal working, is open to temporary or permanent connection. Under suitable conditions will take stock or interest in profits as part compensation for services.

G-197 Junior member, age 27, Stevens graduate, possessing unusual mathematical ability, and with four years experience in experimental, plant and executive work, desires position. At present employed, but will be open for position in July.

G-198 Member A.S.M.E. and A.S.T.M., technical graduate, age 38, four years learning machinist trade, 13 years experience in executive positions with two companies manufacturing brass and iron steam specialties such as valves, lubricators, etc. Familiar with foundry, finishing and assembling operations.

G-199 Associate-member, graduate Swiss Government's mechanical school, command of French and German, eleven years practical experience as machinist, tool-die maker, tool department, foreman, draftsman, machine and tool designer and inspector, familiar with modern manufacturing methods, desires position with opportunity. Capable of handling men.

G-200 Mechanical engineer, technically educated, age 30, married, one and one half years shop experience and ten years practical experience in engineering departments of large concerns manufacturing valves, steam and engineering specialties well versed on power plants; executive ability.

G-201 Mechanical engineer with broad designing experience of steam pumps, open for position as draftsman, hav-

ing held similar position for years with a leading pump concern; best references.

G-202 Student member, age 22, graduate M.E. at Washington University; experienced in drafting, and in oil and cement testing; served time as special apprentice with large company manufacturing iron and steel products; testing or designing; middle west preferred.

G-203 Member, technical graduate, age 32, having two capable associates and centrally located office, will take additional representation in Philadelphia for reputable manufacturer who has at present no direct representative. The character of the product must be such that a considerable business will be a result of thorough and systematic engineering salesmanship.

G-204 Student member, 1915 graduate; four years shop and erecting experience. Location immaterial; future prospects most important consideration.

G-205 Student member, M.E. Columbia University, desires employment with an engineering or manufacturing firm. Willing to start at low salary if there are chances for advancement.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

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The Competent Life, Thomas D. West. *Cleveland, 1905.* Gift of author.

Essays on the development of human ability as an aid in the betterment of labor. Should be read by all who are interested in the improvement of the working man. W. P. C.

Controlling the Cost of Electricity, Walter N. Polakov. Reprint from May 1915, Engineering Magazine. Gift of author.

Cranes and Hoists, Hermann Wilda, translated from the German by Chas. Salter. *London, 1913.* Gift of Hunt Memorial Fund.

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Teaches the doctrine of work in the development of efficiency in man, and the causes of inefficiency. W. P. C.

Exploitación del Petróleo de Comodoro Rivadavia. Memoria Correspondiente á los años 1912/13. *Buenos Aires, 1914.* Gift of R. R. Edgar.

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Tables Annuelles de Constantes et Données Numeriques. Art de L'Ingenieur et Metallurgis. Extrait du volume III, 1912. *Paris, 1914.*

Données numeriques et l'electricité, magnetisme et electrochimie. Extrait du volume III, 1912. *Paris, 1914.* Gift of University of Chicago Press.

These two pamphlets are reprints from the Annual Tables of Constants of the Portions relating (1) to Engineering and Metallurgy; (2) to Electricity, Magnetism and Electro-chemistry, thus placing at the disposal of the student at a small cost the essential standards. W. P. C.

Test Methods for Steam Power Plants, Edward H. Tenney. *New York, D. Van Nostrand Co., 1915.* Gift of publishers.

In connection with a large amount of experimental work done by the author, he has consulted numerous authorities as to testing methods. The methods gathered together in this book are those which he has found most satisfactory in practice. W. P. C.

Valves and Valve Gears, Franklin D. Furman. Ed. 2. Volume I—Steam Engines and Steam Turbines. *New York, J. Wiley & Sons, 1915.* Gift of publishers.

The chief aim has been to tell in particular, instead of in general, just how the engine or motor is regulated; also to tell how the valves and valve gears may be laid out, with due regard to the laws of mechanism, to give desired control of the steam or gas or other operating agent. W. P. C.

### EXCHANGES

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# OFFICERS AND COUNCIL

**President**

John A. Brashear

**Vice-Presidents**

Terms expire December 1915

H. L. Gantt
E. E. Keller
H. G. Reist

Terms expire December 1916

George W. Dickie
Henry Hess
James E. Sague

**Managers**

Terms expire December 1915

Morris L. Cooke
W. B. Jackson
H. M. Leland

Terms expire December 1916

A. M. Greene, Jr.
John Hunter
Elliott H. Whitlock

Terms expire December 1917

Charles T. Main
Max Toltz
Spencer Miller

**Past-Presidents**

Members of the Council for 1915

M. L. Holman
Jesse M. Smith
James Hartness
Alex. C. Humphreys
W. F. M. Goss

**Chairman of Finance Committee**

Robert M. Dixon

**Treasurer**

William H. Wiley

**Honorary Secretary**

Frederick R. Hutton

**Secretary**

Calvin W. Rice

**Executive Committee of the Council**

John A. Brashear, *Chairman*
H. L. Gantt, *Vice-Chairman*
A. M. Greene, Jr.
Henry Hess
James E. Sague
Spencer Miller
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# STANDING COMMITTEES

**Finance**

R. M. Dixon (3), *Chairman;* W. L. Saunders (1), W. D. Sargent (2), W. H. Marshall (4), Alfred E. Forstall (5)

**Meetings**

J. H. Barr (4), *Chairman;* H. E. Longwell (1), H. L. Gantt (2), R. H. Fernald (3), L. P. Alford (5)

**Publication**

C. I. Earll (1), *Chairman;* I. E. Moultrop (2), F. R. Low (3), Fred J. Miller (4), Henry Hess (5)

**Membership**

W. H. Boehm (1), *Chairman;* H. C. Meyer, Jr. (2), L. R. Pomeroy (3), Hosea Webster (4)

**Committee on Standardization**

(To be appointed)

**Library**

L. Waldo (2), *Chairman;* W. M. McFarland (1), J. W. Lieb (3), Jesse M. Smith (4), The Secretary

**House**

S. D. Collett (1), *Chairman;* W. N. Dickinson (2), F. A. Scheffler (3), J. W. Nelson (4), O. P. Cummings (5)

**Research**

R. C. Carpenter (1), *Chairman;* R. H. Rice (2), R. D. Mershon (3), R. J. S. Pigott (4), A. M. Greene, Jr. (5)

**Public Relations**

Morris L. Cooke (4), *Chairman;* J. M. Dodge (1), W. R. Warner (2), G. M. Brill (3), Spencer Miller (5)

**Constitution and By-Laws**

Jesse M. Smith, *Chairman;* Frederick R. Hutton, James E. Sague

Note—Numbers in parentheses indicate number of years the member has yet to serve

## SOCIETY REPRESENTATIVES

**American Association Advancement of Science**

Alex. C. Humphreys, W. B. Jackson

**American Society Testing Materials**
**Modification Briggs Standard for Pipe Threads**

Stanley G. Flagg, Jr., John C. Bannister

**Conference Committee on Electrical Engineering Standards**

H. G. Stott, *Chairman;* A. F. Ganz, Carl Schwartz

**Conference Committee of National Engineering Societies and A. S. T. M.**

C. W. Baker, A. M. Greene, Jr.

**Conservation**

G. F. Swain, *Chairman;* C. W. Baker, L. D. Burlingame, M. L. Holman, Calvin W. Rice

**The Engineering Foundation**

Jesse M. Smith, Alex. C. Humphreys

**Joint Committee International Engineering Congress 1915**

The President, The Secretary, C. T. Hutchinson, Thos. Morrin, T. W. Ransom, C. R. Weymouth

**John Fritz Medal**

John A. Brashear (1), Frederick R. Hutton (2), John R. Freeman (3), Ambrose Swasey (4)

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# OFFICERS OF THE STUDENT BRANCHES

| INSTITUTION | DATE AUTHORIZED BY COUNCIL | HONORARY CHAIRMAN | CHAIRMAN | CORRESPONDING SECRETARY |
|---|---|---|---|---|
| Armour Inst. of Tech. | Mar 9, 1909 | G. F. Gebhardt | J. M. Byanskas | E. S. Eehlin<br>Armour Inst. of Tech., Chicago, Ill. |
| Carnegie Inst. of Tech. | Oct 14, 1913 | W. Trinks | J. R. Cline | Julius Guter<br>303 Dithridge St., Pittsburgh, Pa. |
| Case School of Applied Science | Feb 14, 1913 | F. H. Vose | L. W. Hodons | Burton S. Dake<br>1886 E. 75th St., Cleveland, O. |
| Columbia Univ. | Nov 9, 1909 | Chas. E. Lucke | H. F. Allen | A. S. Henry<br>333 Central Park W., New York, N. Y. |
| Cornell Univ. | Dec 4, 1908 | R. C. Carpenter | A. R. Cota | W. F. Courtney<br>Telluride Assoc., Ithaca, N. Y. |
| Georgia Sch. of Tech. | Feb 13, 1915 | | | W. T. McCullough, Jr.<br>55 W. North Ave., Atlanta, Ga. |
| Kansas State Agri. College | Feb 13, 1914 | A. A. Potter | L. A. Wilsey | F. R. Rawson<br>Kan. State Agri. College, Kan. |
| Lehigh Univ. | June 2, 1911 | P. B. de Schweinitz | C. H. Shuttler | W. C. Hartman<br>Lehigh Univ., South Bethlehem, Pa. |
| Leland Stanford Jr. Univ. | Mar 9, 1909 | W. F. Durand | W. H. Warren | F. G. Hampton<br>313 Kipling St., Palo Alto, Cal. |
| Mass. Inst. of Tech. | Nov 9, 1909 | E. F. Miller | K. C. Richmond | C. E. Shedd<br>74 Lakeview Ave., Haverhill, Mass. |
| New York Univ. | Nov 9, 1909 | C. E. Houghton | | |

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| Ohio State Univ. | Jan 10, 1911 | Wm. T. Magruder | H. Burnham | S. J. Cobb<br>Ohio State Univ., Columbus, O. |
| Penn. State College | Nov 9, 1909 | J. P. Jackson | H. L. Mummert | E. J. Kenney<br>Pa. State College, State College, Pa. |
| Poly. Inst. of Brooklyn | Mar 9, 1909 | W. D. Ennis | H. Brandt | Charles E. Rohmann<br>Poly. Inst. of Brooklyn, Brooklyn, N. Y. |
| Purdue Univ. | Mar 9, 1909 | G. A. Young | W. T. Miller | L. C. McAnley<br>Purdue Univ., Lafayette, Ind. |
| Rensselaer Poly. Inst. | Dec 9, 1910 | A. M. Greene, Jr. | C. P. Brown | W. Kelly<br>374 Clinton Ave., Albany, N. Y. |
| State Agri. College (Colo.) | Oct 9, 1914 | J. W. Lawrence | A. T. Johnson | T. H. Sackett<br>State Agri. College, Fort Collins, Colo. |
| State Univ. of Iowa | Apr 11, 1913 | R. S. Wilbur | C. W. Harrison | Victor Johnson<br>Cedar Rapids, Ia. |
| State Univ. of Kentucky | Jan 10, 1911 | F. P. Anderson | M. Brooke | T. R. Nunan<br>345 S. Limestone St., Lexington, Ky. |
| Stevens Inst. of Tech. | Dec 4, 1908 | Alex. C. Humphreys | F. F. Blixt, Jr. | R. F. Hohman<br>Stevens Inst. of Tech., Hoboken, N. J. |
| Syracuse Univ. | Dec 3, 1911 | W. E. Ninde | D. R. Hay | H. B. Tracy<br>Fayetteville, N. Y. |
| Throop College of Tech. | Nov 13, 1914 | W. H. Adams | R. O. Catland | H. A. Black<br>32 N. Grand Oaks Ave., Pasadena, Cal. |
| Univ. of Arkansas | Apr 12, 1910 | B. N. Wilson | M. McGill | C. Bethel<br>Univ. of Ark., Fayetteville, Ark. |
| Univ. of California | Feb 13, 1912 | Joseph N. LeConte | A. C. Moorhead | H. L. McLean<br>Univ. of Cal., Berkeley, Cal. |
| Univ. of Cincinnati | Nov 9, 1909 | J. T. Faig | A. J. Langhammer | W. T. Lowell<br>309 Ludlow Ave., Cincinnati, O. |
| Univ. of Colorado | Apr 10, 1914 | J. A. Hunter | E. B. Good | Wilfred Sawyer<br>970 11th St., Boulder, Colo. |
| Univ. of Illinois | Nov 9, 1909 | W. F. M. Goss | R. C. Maley | E. B. Stout<br>Univ. of Illinois, Urbana, Ill. |
| Univ. of Kansas | Mar 9, 1909 | P. F. Walker | J. Stillwell | A. J. Nigg<br>1324 Vermont St., Lawrence, Kan. |
| Univ. of Maine | Feb 8, 1910 | Arthur C. Jewett | W. L. Wark | H. A. Titcomb<br>Phi Kappa Sigma House, Orono, Me. |
| Univ. of Michigan | Apr 10, 1914 | John R. Allen | W. W. Tuttle | H. S. Manwaring<br>1666 Broadway, Ann Arbor, Mich. |
| Univ. of Minnesota | May 12, 1913 | W. H. Kavanaugh | D. M. Giltinan | R. R. Boyles<br>1738 Grand Ave., St. Paul, Minn. |
| Univ. of Missouri | Dec 7, 1909 | H. Wade Hibbard | L. L. Leach | I. O. Royse<br>Albany, Mo. |
| Univ. of Nebraska | Dec 7, 1909 | J. D. Hoffman | L. L. Westling | R. B. Saxon<br>Univ. of Neb., Lincoln, Neb. |
| Univ. of Wisconsin | Nov 9, 1909 | J. G. D. Mack | J. B. Wilkinson | G. C. Richardson<br>Univ. of Wis., Madison, Wis. |
| Virginia Poly. Inst. | Jan 8, 1915 | L. S. Randolph | R. C. Brauer | H. F. Watson<br>Va. Poly. Inst., Blacksburg, Va. |
| Washington Univ. | Mar 10, 1911 | E. L. Ohle | R. V. Henkel | E. C. Schisler<br>Washington Univ., St. Louis, Mo. |
| Worcester Poly. Inst. | June 16, 1914 | W. W. Bird | Harold Nutt | H. P. Fairfield |
| Yale Univ. | Oct 11, 1910 | L. P. Breckenridge | R. F. Frost | W. S. Snead<br>96 Wall St., New Haven, Conn. |

# THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 AUGUST 1915 Number 8


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# COMING MEETINGS OF THE SOCIETY

*September* 16–17, *San Francisco, Cal.* In common with the other national engineering societies, professional sessions will be held in San Francisco, September 16 and 17, previous to the meetings of the International Engineering Congress, which will occur during the week of September 20. Papers will be presented on the Exhibits and Engineering Features of the Panama-Pacific International Exposition, and on Oil Engines, with special reference to their use with California oils. The sessions will be held in the Hall of the Native Sons of the Golden West, Mason Street, between Geary and Post Streets. The headquarters of the Society will be at the Clift Hotel.

*Annual Meeting, December* 7–10, *New York City.* Arrangements have already been perfected for sessions by the sub-committees on Railroads, Textiles, and Protection of Industrial Workers, and it is expected that papers will also be contributed by the Committees on Machine Shop Practice, Industrial Buildings, and Air Machinery, besides the usual miscellaneous papers. The Railroad session will be devoted to a discussion of trucks for passenger coaches. The Textile session will have papers by engineers prominent in the textile field, on the relative values of purchased electric current, and of power from individual plants; hot water heating for textile mills; and the engineering features of insurance. The session on safety methods will be of interest to engineers generally. It is planned to have a discussion along broad lines, taking up the principles involved and the results obtained by safety methods, and their bearing on industry as a whole. *It is urged by the Committee on Meetings that all papers for the Annual Meeting be sent to the Secretary not later than September 1st, and that those who contemplate contributing papers notify the Secretary in advance of this date if possible. Papers should be typewritten, double or triple spaced, and drawings should be of such a character that tracings can be readily made from them for purposes of reproduction.*

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 August 1915 Number 8


## THE SEPTEMBER MEETING

AND

## THE INTERNATIONAL ENGINEERING CONGRESS, 1915

THE centre of gravity of the engineering profession in September will be the International Engineering Congress to be held in San Francisco during the week of the twentieth, and for this reason the September meetings of the four national engineering societies have been arranged to take place in that city during the week preceding the Congress. Also, members of the societies attending the meeting and Congress will be afforded the unique opportunity of visiting the Panama-Pacific International Exposition at San Francisco, the Panama-California Exposition at San Diego, as well as some of this country's most famous points of scenic interest on the route from the east to the west.

The Committee on Local Affairs in San Francisco has placed its services at the disposal of all engineers resident within the United States, so that those who visit San Francisco with their families and friends may be sure that special attention will be paid to their comfort.

### THE JOURNEY TO SAN FRANCISCO

Arrangements have been made for a special train for members of the Society and their friends, leaving New York (Grand Central Terminal) on Thursday, September 9, at 7.45 P.M. The train will stop at Niagara Falls for four hours on Friday morning, allowing time for the members of the party who so desire to take the famous Niagara Gorge Trip. On Sunday morning the party will arrive at Colorado Springs, where members will be enabled to tour Crystal Park and also journey to Pike's Peak, Garden of the Gods, Cheyenne Canyon and the Seven Falls. The Grand Canyon will be reached on Tuesday morning and fifteen hours will be spent there, which is ample time for excursions to Bright Angel Trail, Bottom of Canyon, Hopi Point, Hermit Rim Drive and Sunset Point. The party will arrive at San Francisco on Wednesday, September 15, at 9 A.M.

Tower of Jewels
Panama-Pacific Exposition

Reservations for this train are now being arranged by Mr. G. S. Harner, Passenger Agent, New York Central Lines, 1216 Broadway, New York City, and to secure desirable accommodations applications should be addressed directly to Mr. Harner as early as possible, mentioning the Society. The fare to San Francisco by this train and return by any route (except via Northwestern points) is $98.80. Pullman rates, one way: $22.00, lower berth; $17.60, upper berth.

For those members of the Society who cannot join the party from New York, reservations are being made on the Sunset Limited, leaving New Orleans on Sunday, September 12, at 11 A.M., and arriving in San Francisco at 1.00 P.M. on Wednesday, September 15. Accommodations on this train can now be secured by addressing Mr. J. H. R. Parsons, General Passenger Agent, Southern Pacific Company, New Orleans, La. The round trip fare, New Orleans to San Francisco, is $57.50 going and

New York State Building

Avenue of Progress

returning over the same route, or \$62.50 returning to Chicago. Pullman rates, one way: \$11.50, lower berth; \$9.20, upper berth.

THE SEPTEMBER MEETING

The professional sessions of the September meeting of the Society will be held in the Hall of the Native Sons of the Golden West, Mason Street, between Geary and Post, San Francisco, on the mornings of Thursday, September 16, and Friday, September 17. While the program has not been fully completed, it can be stated that there will be papers on Thursday morning treating comprehensively of the exhibits and the engineering features of the Panama-Pacific International Exposition, and on Friday there will be papers and discussion on the subject of the oil engine with special reference to its use with California oils.

HEADQUARTERS IN SAN FRANCISCO

The headquarters of the Society will be the Clift Hotel, at the corner of Geary and Taylor Streets, San Francisco. For members who desire to be accommodated at this hotel, a number of rooms have been arranged for. The rate is \$5.50 for each room, to be occupied by one or two persons, and to include bath. Each member should make his own reservation direct with the hotel, mentioning the Society.

For convenience, the rates at other hotels as quoted to the Society are given below:

Palace Hotel, Market and New Montgomery Streets, \$4.00 per day, room and bath, one person.

Fairmont Hotel, California and Mason Streets, \$4.00 per day, room and bath, one person.

Hotel St. Francis, Geary and Powell Streets, \$7.00 per day up, room and bath, two persons.

Hotel St. Regis, 83 Fourth Street, \$2.50 per day up, room and bath, two persons.

Information regarding accommodations at any other hotels may be obtained by addressing the Official Exposition Hotel Bureau, 702 Market Street, San Fran-

Varied Industries and Mines

Court of Four Seasons

Palace of Education

Column of Progress

cisco. This Bureau also undertakes to make reservations in approved hotels without charge.

MEETINGS OF OTHER SOCIETIES

The American Society of Civil Engineers, the American Institute of Mining Engineers, and the American Institute of Electrical Engineers will also hold September meetings in San Francisco on the days preceding the Congress.

The headquarters of these societies and their places of meeting are listed below:

| *Society* | *Headquarters* | *Meetings* |
|---|---|---|
| A. S. C. E. | St. Francis Hotel | Same |
| A. I. M. E. | Hotel Bellevue | Same |
| A. I. E. E. | St. Francis Hotel | Civil Center Auditorium |

The meeting of the American Society of Civil Engineers is the Forty-seventh Annual Convention of the Society. The programme includes a welcoming address by President Charles D. Marx; a Panama Canal session; a reception, dinner and dance in the Old Faithful Inn on the grounds of the Panama-Pacific International Exposition, and excursions to Del Monte, Santa Cruz and San José. The Society, through its Secretary, Chas. Warren Hunt, has extended a cordial invitation to the membership of our Society to participate in these events. The dates of this convention are September 16 to 18.

INTERNATIONAL ENGINEERING CONGRESS, 1915

The holding of a Congress of Engineers from the great associations of the world on the scene of the celebration of the completion of the Panama Canal was conceived as far back as 1912. In February of that year a convention of engineering societies was held in San Francisco, and as the outcome of the recommendations there made the International Engineering Congress, 1915, was organized.

Indefatigable have been the efforts of the Committee of Management of the Congress to secure the success

Palace of Manufactures

Colonnades, Court of Four Seasons

of the enterprise by the coöperation of members from the national engineering societies. The last report of this committee announced that practically three thousand members had been enrolled and almost two hundred papers had been received.

The Congress will publish ten volumes of proceedings on the following topics: The Panama Canal; Waterways, Irrigation; Municipal Engineering; Railways, Railway Engineering; Materials of Engineering Construction; Mechanical Engineering; Electrical Engineering, Mechanical Engineering; Mining Engineering, Metallurgy; Naval Architecture and Marine Engineering; miscellaneous, including Military Engineering, Aeronautical Engineering, and Heating and Ventilation.

Members of the Society still have an opportunity of enrolling in the Congress if they wish to do so. The fee is nominal, five dollars, and entitles the subscriber to a certificate of membership, to participation in the deliberations of the Congress, to an index volume of the proceedings, and to one of the volumes listed above. Remittances may be made to Mr. W. A. Cattell, Secretary, Foxcroft Building, San Francisco.

The Congress will be opened at 10 A.M. on Monday, September 20, in the new Auditorium Building, where the subsequent sessions will be held. At the opening session there will be addresses of welcome and responses, an address by General George W. Goethals, Honorary President, and the presentation of the John Fritz Medal to Dr. James Douglas. The second session will be devoted to the Panama Canal, and sessions on the topics mentioned above will follow through the week.

### EXCURSIONS IN AND AROUND SAN FRANCISCO

For the benefit of members visiting San Francisco for the September meeting and the Congress, the following excursions to important engineering activities in California have been arranged. Some of these will be by automobile without expense, and others will only entail the cost of a round trip ticket.

September 18: San Francisco High Pressure Fire System.
Portrero Gas Works Electric Station A, Pacific Gas & Electric Co.
Spring Valley Water Works.

September 19: Delta Lands of the Sacramento and San Joaquin Rivers.
Spring Valley Water Works.

September 17 to 18: Great Western Power Company's Hydroelectric development on the Feather River.
Gold dredging at Oroville.

September 18 to 19: Pacific Gas & Electric Co.'s Hydroelectric development at Lake Spaulding and Drum Power House.
North Star & Empire Mines at Grass Valley.

September 17 to 19: Oil fields at Coalinga.

### THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION

Of the eleven main exhibit palaces of the Exposition, some of which are here illustrated, those of particular interest to the members of the Society will be the Manufactures and Varied Interests Building; the Machinery Building; the Mines and Metallurgy Building, and the Education Building.

The great palace of Machinery is the largest on the Exposition site and is nearly a thousand feet in length. In this palace numerous groups comprising examples of steam generators and motors, internal combustion motors, hydraulic motors, and wood and metal working tools are shown.

The exhibits in the palace of Mines and Metallurgy deal with the natural mineral resources of the world, their conversion into metal and manufacture in raw materials and forms for the various industries.

Education is represented by examples including methods of vocational training and municipal training, in addition to general educational work of schools and universities.

The Manufactures and Varied Industries palace contains products of manufacture and manual skill from all nations of the world.

### THE PANAMA-CALIFORNIA EXPOSITION

Now being held at San Diego, California, this is also within easy reach of those visiting the Pacific Coast. This Exposition is also in commemoration of the opening of the Panama Canal, but its theme is the exploitation of the possibilities and opportunities of the various sections of this coast, from Alaska to Peru.

The Exposition is staged in Balboa Park, in the heart of the city of San Diego, and its exhibits are grouped in an educational and attractive manner in twelve buildings.

### THE RETURN FROM SAN FRANCISCO

Members of the party journeying to San Francisco by the Engineers' Special have the privilege of returning by one of several routes, of which the following are examples:

Via Southern Pacific or Western Pacific to Ogden and Salt Lake City, over the Rocky Mountains to Denver or Cheyenne, thence via Chicago or St. Louis.

Via Los Angeles, San Pedro Route to Salt Lake City, and thence as above.

Via Los Angeles, the Santa Fé Route through Albuquerque (also Denver if desired) to Chicago.

Via Los Angeles, El Paso and the Rock Island Route to Chicago.

Via Los Angeles and El Paso to New Orleans, thence via St. Louis, Chicago or Cincinnati.

Via Portland, Tacoma, or Seattle, thence via Ogden and Salt Lake City and the Rocky Mountains to Cheyenne or Denver, and Chicago or St. Louis.

Via Portland, Tacoma and Seattle to St. Paul, thence via Chicago.

Via Portland and Tacoma to Seattle, steamer or rail to Vancouver, thence via the Canadian Rockies, Winnipeg and St. Paul to Chicago.

Mr. Harner, the New York Central Lines agent, will quote any member the rates for return by any of the above or any other routes.

## NAVY ADVISORY BOARD

Following the announcement in the daily papers of the organization of an Advisory Board for the U. S. Navy, of which Thomas A. Edison is Chairman, the Society received an invitation from the Honorable Josephus Daniels, the Secretary of the Navy, asking the appointment of two members to serve on the Board.

Similar invitations have been extended to several other scientific and engineering societies, with a view to having the Board representative of the most advanced thought and experience in the various lines of engineering activity and scientific research.

Inasmuch as there will be no regular meeting of the Council until October, the Executive Committee of the Council took the matter under consideration and have arranged for a ballot by the Council by which means it is expected that an early selection of representatives will be made. It is the desire that the appointees to the Advisory Board should be distinctly representative of the mechanical engineers of the country and the aim will be to select men of foresight and executive ability in combination with inventive talent.

## JOINT COMMITTEE ON STANDARDS FOR GRAPHIC PRESENTATION

### PRELIMINARY REPORT PUBLISHED FOR THE PURPOSE OF INVITING SUGGESTIONS FOR THE BENEFIT OF THE COMMITTEE[1]

As a result of invitations extended by The American Society of Mechanical Engineers, a number of associations of national scope have appointed representatives on a Joint Committee on Standards for Graphic Presentation. Below are the names of the members of the committee and of the associations which have coöperated in its formation.

Willard C. Brinton, *Chairman*, American Society of Mechanical Engineers. [7 East 42nd Street, New York City.]

Leonard P. Ayres, *Secretary*, American Statistical Association. [130 East 22nd Street, New York City.]

N. A. Carle, American Institute of Electrical Engineers.

Robert E. Chaddock, American Association for the Advancement of Science.

Frederick A. Cleveland, American Academy of Political and Social Science.

H. E. Crampton, American Genetic Association.

Walter S. Gifford, American Economic Association.

J. Arthur Harris, American Society of Naturalists.

H. E. Hawkes, American Mathematical Society.

Joseph A. Hill, United States Census Bureau.

Henry D. Hubbard, United States Bureau of Standards.

Robert H. Montgomery, American Association of Public Accountants.

Henry H. Norris, Society for the Promotion of Engineering Education.

Alexander Smith, American Chemical Society.

Judd Stewart, American Institute of Mining Engineers.

Wendall M. Strong, Actuarial Society of America.

Edward L. Thorndike, American Psychological Association.

The committee is making a study of the methods used in different fields of endeavor for presenting statistical and quantitative data in graphic form. As civilization advances there is being brought to the attention of the average individual a constantly increasing volume of comparative figures and general data of a scientific, technical and statistical nature. The graphic method permits the presentation of such figures and data with a great saving of time and also with more clearness than would otherwise be obtained. If simple and convenient standards can be found and made generally known, there will be possible a more universal use of graphic methods with a consequent gain to mankind because of the greater speed and accuracy with which complex information may be imparted and interpreted.

THE FOLLOWING ARE SUGGESTIONS WHICH THE COMMITTEE HAS THUS FAR CONSIDERED AS REPRESENTING THE MORE GENERALLY APPLICABLE PRINCIPLES OF ELEMENTARY GRAPHIC PRESENTATION

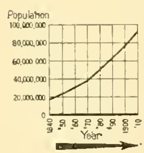


Fig. 1

1. The general arrangement of a diagram should proceed from left to right.

Fig. 2

2. Where possible represent quantities by linear magnitudes as areas or volumes are more likely to be misinterpreted.

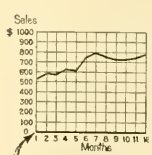


Fig. 3

3. For a curve the vertical scale, whenever practicable, should be so selected that the zero line will appear on the diagram.

[1] Copies may be had from The American Society of Mechanical Engineers, 29 West 39th St., New York: 5 cents to members; 10 cents to non-members.

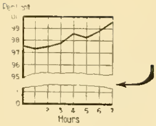



Fig. 4

4. If the zero line of the vertical scale will not normally appear on the curve diagram, the zero line should be shown by the use of a horizontal break in the diagram.

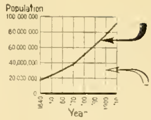



Fig. 10

10. The curve lines of a diagram should be sharply distinguished from the ruling.

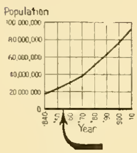



Fig. 5A

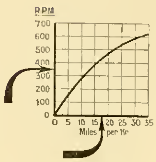



Fig. 5B

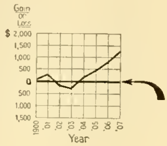



Fig. 5C

5. The zero lines of the scales for a curve should be sharply distinguished from the other coördinate lines.

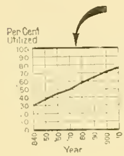



Fig. 6A

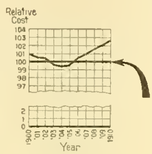



Fig. 6B

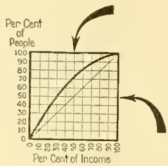



Fig. 6C

6. For curves having a scale representing percentages, it is usually desirable to emphasize in some distinctive way the 100 per cent line or other line used as a basis of comparison.

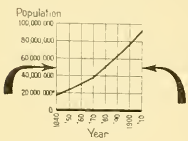



Fig. 7

7. When the scale of a diagram refers to dates, and the period represented is not a complete unit, it is better not to emphasize the first and last ordinates, since such a diagram does not represent the beginning or end of time.

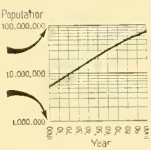
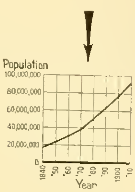



Fig. 8

8. When curves are drawn on logarithmic coördinates, the limiting lines of the diagram should each be at some power of ten on the logarithmic scales.



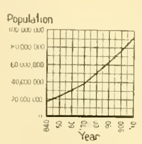
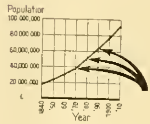
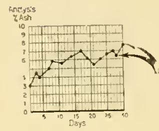




Fig. 9A Fig. 9B

9. It is advisable not to show any more coördinate lines than necessary to guide the eye in reading the diagram.



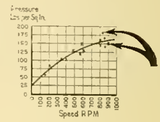




Fig. 11A Fig. 11B Fig. 11C

11. In curves representing a series of observations, it is advisable, whenever possible, to indicate clearly on the diagram all the points representing the separate observations.

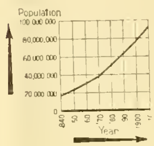
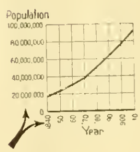
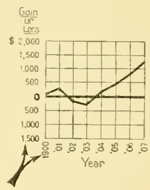



Fig. 12

12. The horizontal scale for curves should usually read from left to right and the vertical scale from bottom to top.



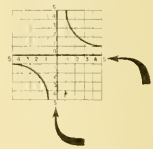
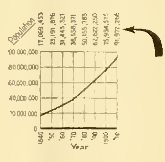
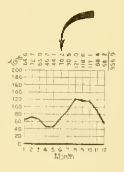



Fig. 13A Fig. 13B Fig. 13C

13. Figures for the scales of a diagram should be placed at the left and at the bottom or along the respective axes.



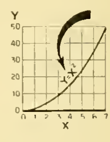
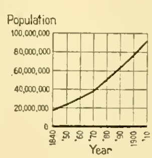




Fig. 14A Fig. 14B Fig. 14C

14. It is often desirable to include in the diagram the numerical data or formulae represented.




| Year | Population |
|---|---|
| 1840 | 17,069,453 |
| 1850 | 23,191,876 |
| 1860 | 31,443,321 |
| 1870 | 38,558,371 |
| 1880 | 50,155,783 |
| 1890 | 62,622,250 |
| 1900 | 75,994,575 |
| 1910 | 91,972,266 |

Fig. 15

15. If numerical data are not included in the diagram it is desirable to give the data in tabular form accompanying the diagram.

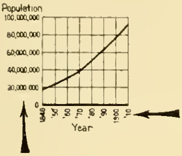
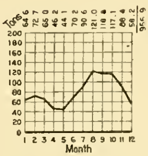



Fig. 16

16. All lettering and all figures on a diagram should be placed so as to be easily read from the base a<sup></sup>t the bottom, or from the right-hand edge of the diagram as the bottom.




Aluminum Castings Output of Plant No. 2, by Months, 1914
output is given in short tons
sales of scrap aluminum are not included
Fig. 17

17. The title of a diagram should be made as clear and complete as possible. Sub-titles or descriptions should be added if necessary to insure clearness.

## LIBRARY SERVICE BUREAU

With a view to bringing closer to members the facilities and usefulness of our splendid technical library, the Library Board has inaugurated a Service Bureau whose duty it will be to maintain a staff of expert searchers and translators to insure prompt and thoroughly efficient service to those members who live at such distance from New York as to make it inconvenient for them to consult personally the books and periodicals, and to those New York members who desire to avail themselves of this service.

Members who desire to be kept posted on the current publications of any engineering subject may receive such service by signing a form which states:

> I hereby subscribe $10.00 for Library Service for one year from date with the understanding that the subscription shall apply on service which I may request with reference to the following:
> Reference cards
> Translating
> Copying
> Bibliographing
> Abstracting
> Searches for patent purposes
> Statistical searches and reports

The Library is not permitted to carry on any work of a commercial character and, therefore, the prices charged members for service are kept down to a merely self-supporting basis. For the purpose of economic administration the subscription feature previously referred to has been established.

Forms have been prepared for the use of those desiring to receive regular service which give the schedule of charges for the different classes of service.

All the work done by the Library Service Bureau is strictly confidential, and this feature is especially important in relation to searches made for patent purposes.

At present there are in the Library over sixty thousand volumes on technical subjects, and there are received currently over one thousand engineering or scientific periodicals. In addition, the searchers have ready access to the New York Public Library and the Library of the Chemists Club.

For those members who are personally able to use the library a bibliography on any subject will, on request, be prepared by the Bureau, and with adequate prior notice, the volumes relating thereto will be set apart for personal perusal.

It is desired that all members shall become better acquainted with the facilities of the splendid library they own, and with the advantages which can be secured by those who avail themselves of the aid furnished by its Service Bureau.

## APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON SEPTEMBER 10, 1915

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages would qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of grading are also posted.

*The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Society by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned.* All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before September 10, 1915.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Annis, Lawrence F., Supt. of Constr., Southwark Fdy. & Mch. Co., Philadelphia, Pa.

Atkinson, Herbert S., Prod. and Designing Engr., Clam Shell Bucket Dept., The Hayward Co., New York.

Bell, Paul J., Mgr., San Carlos Milling Co., Ltd., San Carlos, Philippine Islands.

Bennett, Charles F., Supt., Standard Plunger Elev. Co., Worcester, Mass.

Cudlipp, Charles W., Supt. and Secy., The Rogers Paper Mfg. Co., Inc., So. Manchester, Conn.

Davis, Richard G., Jr., Apprentice, Brown & Sharpe Mfg. Co., Providence, R. I.

Ferguson, John F., Genl. Mech. and Elec. Engr., Williston, N. Dak.

Ferguson, Richard, Mgr., The Grant Lees Gear Co., Cleveland, Ohio.

Harvey, Richard P., Rep., The Blaw Steel Construction Co., Pittsburgh, Pa., and The Concrete Form Co., Inc., Syracuse, N. Y., at San Francisco, Cal.

Norris, Earle B., Assoc. Prof. of Mech. Engrg., The Univ. of Wis., Madison, Wis.

Osborne, Loyall A., Vice-Pres., Westinghouse Elec. & Mfg. Co., New York.

Patterson, Henry R., Supt. Trenton Wks., American Steel & Wire Co., Trenton, N. J.

Poole, Ernest J., Supt., The Carpenter Steel Co., Reading, Pa.

Rogers, Ulysses G., Ch. Engr. and Master Mech., M. S. Ortendorf & Co., Chicago, Ill.

Smetters, Samuel T., Asst. Bridge Engr., The Sanitary Dist., Chicago, Ill.

Von Schlegell, Frederick, Dist. Mgr., Allis-Chalmers Mfg. Co., Chicago, Ill.

Walther, Paul H., Vice-Pres., H. R. Heinicke, Inc., New York.

Whitney, Herbert A., Cons. Engrg. Work, Whitney Engrg. Co., Tacoma, Wash.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bown, Carlos W., Genl. Foreman of Mch. Shop, Chile Exploration Co., Chuquicamata, Chile.

Cove, James R., Master Mech., Mass. Cotton Mills, Lowell, Mass.

Ebeling, Frederic O., Engr. and Draftsman, Robins Conveying Belt Co., New York.

Fisk, Gustaf L., Designer, Cambria Steel Co., Johnstown, Pa.

Jackson, John R., Asst. Engr. of Tests, A. T. & S. F. Railway Co., Chicago, Ill.

FOR CONSIDERATION AS JUNIOR

Hubbell, Richard L., Inspector, with D. C. & W. B. Jackson, Newark, N. J.

Jackson, Earl E., Mech. and Cons. Engr., New York.

Johnson, Adolph T., Student, Denver, Colo.

Kite, Henry J., Asst. Maintenance Engr., Chester Plant, American Steel Foundries, Chester, Pa.

McBride, Francis R., Grad. Student of Cornell Univ., Portland, Ore.

MacEwan, Thomas S., with American Radiator Co., New York.

Van Valkenburgh, Merritt, Draftsman, Pwr. Installation Dept., De La Vergne Mch. Co., New York.

Walters, William T., Inspector, Mech. Dept., Illinois Central R.R., Memphis, Tenn.

Weber, Samuel, Jr., Home Off. Engr., Globe Indemnity Co., New York.

## APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Bond, Francis M., Mech. Engr., Remington Typewriter Co., Ilion, N. Y.

Brooks, Louis C., Elec. Engr., General Elec. Co., Schenectady, N. Y.

Robbins, John L., Mech. Engr., Robbins, Gamwell & Co., Pittsfield, Mass.

## SUMMARY

| | |
|---|---|
| New Applications | 32 |
| Applications for change of grading: | |
| Promotion from Junior | 3 |
| | 35 |

## APPLICATIONS TO BE IN TIME FOR THE ANNUAL MEETING MUST BE ON FILE BY AUGUST 23

The fact that it takes at least three months to complete an election to membership, makes it necessary to post, in the September issue of The Journal, applications for membership which are to be acted upon in season for successful candidates to attend the Annual Meeting as members of the Society.

Members who have friends wishing to join the Society this year will be interested in having this information available, as many do not realize that it is necessary to take action so far in advance.

This is the most desirable time of the year at which to apply, because newly-elected members not only have the privilege of participating in the Annual Meeting, but obtain membership in time to have their names included in the Year Book of the Society, which goes to press annually on January 2d; they also have the opportunity of taking part in any of the meetings held by Local Sections in fourteen of the principal industrial centers of the country.

The advantages offered members are being constantly increased with an aim to fill completely the broad field of usefulness of a national engineering society, efficiently advance the interests of the profession as a whole and be especially helpful to every member of the organization.

Information regarding the Society and the requirements for membership will be promptly forwarded to any persons suggested by members.

# SPRING MEETING PAPERS

*At the Spring Meeting held at Buffalo, June 22-25, fourteen papers were presented, comprehensive abstracts of which are to be published in The Journal with an account of the discussion. Pamphlet copies of the complete papers without the discussion are available at the prices named in each case. Later, the papers which appear in volume 37 of Transactions may be had in pamphlet form with the discussion added.*

## A STUDY OF AN AXLE SHAFT FOR A MOTOR TRUCK

BY JOHN YOUNGER, BUFFALO, N. Y.

Member of the Society

While the investigation herein described is one which the writer made to determine the cause of failure of an axle shaft for a large motor truck and also the remedy adopted, it has a very much wider application than to motor trucks, and is testimony to the value of heat-treated steels.

The shaft is shown in Fig. 7 and with its adjacent parts in Fig. 1. The flutes or splines at the ends are slightly free so that the shaft is under no constraint except to move in a rotary path; in other words it is intended to be subject to pure torsional stresses, with no complicating bending effects. The shaft was made from $2\frac{1}{4}$-in. diameter chrome nickel bar, turned all over to 2.1235 in. diameter. The shafts broke in service as shown by the illustrations, Figs. 2, 3, 4, and 5. The specifications of the steel read as follows:

| Chemical | Per cent. | Physical | Lb. per sq. in. |
|---|---|---|---|
| Carbon about | .20 | Elastic limit | 90,000 |
| Chromium about | 1 5 | Maximum strength | 105,000 |
| Manganese about | .30 | | Per cent. |
| Nickel about | 4.00 | Reduction in area | 66 |
| Silicon about | .20 | Elongation | 25 |
| Phosphorus and sulphur below | .04 | | |

The following are the particulars of the motor truck upon which all calculations of strength must be based:

Motor develops 44 h.p. at 1000 r.p.m. under average conditions.

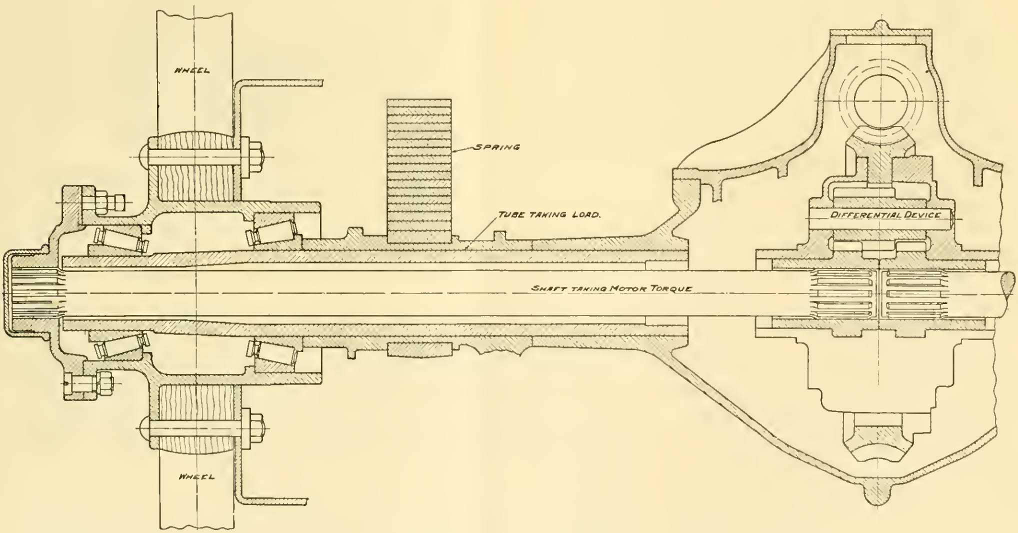



Fig. 1 Diagrammatic Design of Truck Rear Axle showing Location of Shaft

Transmission reduction is 3.77 to 1.

Worm gear reduction is 9.75 to 1.

Total reduction, 36.8 to 1.

From various tests the efficiency of the transmitting mechanism between motor and axle shafts on this gear ratio is about 75 per cent., so that therefore 33 h.p. are transmitted as a maximum by the shafts at 27 r.p.m. But, in common with usual road vehicle practice, a differential gear is fitted, so that the power transmitted by each shaft at the wheel is only half the total; the shaft shown in Fig. 7, therefore, is under maximum pure torsional stress due to the transmission of $16\frac{1}{2}$ h.p. at 27 r.p.m.

[1] Presented at the Spring Meeting of the Society, June 1915. Complete paper may be obtained without discussion; 5 cents to members; 10 cents to non-members.

FIG. 2 CHARACTERISTIC FRACTURE, SHAFT TURNED DOWN

In considering the effective diameter on which to base calculations of stress, the large diameter of $2\frac{1}{8}$ in. would not be accurate, inasmuch as the flutes at the ends weaken the shaft to a considerable extent, as is obvious from Figs. 2 to 5, where the lines of cleavage are clearly seen to start from the corner of the spline. While it is true that a sharp corner is a very dangerous source of weakness, it was impossible to get a radius of more than 0.02 in. at the fillet without reducing the area of bearing surface. Key seats or splines are always weakening elements, but it is unfortunately impossible to do without them. The diameters of the plain shafts were the same as the diameters of the splined shafts at the bottom of the key-ways. The limit of elasticity and the torque at fracture for the splined pieces are seen to be slightly greater than that for the plain. Yet, when we turn to the work required to produce fracture, we find it takes more energy to break the plain shaft than it does the splined. It would certainly seem as if the projections should give an added strength to the shaft; yet in the ultimate their presence seems to hasten its down-fall. This is borne out by the appearance of the fractures in Figs. 3, 4, and 5, and it would seem that, while the splines add a slight extra strength to the shaft under static conditions, they subtract from it under dynamic conditions where fatigue is likely to result.

Taking the energy required to fracture, a plain shaft could be considered 30 per cent. to 60 per cent. stronger than a shaft with splines added. The immediate conclusion therefore would be that calculation for strength should be based at most on the diameter at the bottom of the splines.

In order to try out practically the value of this conclusion, a truck was loaded up to full 5 tons capacity. Its rear wheels were then anchored somewhat in a cradle, which would allow about 6 ft. of travel, Fig. 10. A driver then made the truck surge to and fro, the extent of the alternations being measured. The idea was to give the maximum stress on the axles by obtaining the full force of the motor as well as the rotational energy of the flywheel acting against the inertia of the truck. One shaft was left parallel in its length, the other was turned down in the centre. The former broke first and the latter some little time after, 5141 blows being necessary. The total twist in the second exceeded 700 deg., whereas the twist in the first was through an exceedingly short length, all being concentrated near the end of the splines (Fig. 5). It is interesting to note in Fig. 6 the beginning of the planes of cleavage.

From this test the conclusion is justified that the diameter at the bottom of the splines is to be taken in calculations for strength. Accordingly, the design was changed to that of Fig. 8 in which the diameter at the bottom of the splines is 1.75 in. The shaft formula therefore gives

$$\text{Maximum stress per square inch} = \frac{321{,}000 \text{ h.p.}}{nd^3}$$

$$= 36{,}500 \text{ lb. per sq. in., approx.}$$

This gives a factor of safety of 2.5 based on the elastic limit, or 2.9 based on maximum tensile strength.

FIG. 3 CHARACTERISTIC FRACTURE, PARALLEL SHAFT

Regarding braking problems, this particular design of truck has a powerful brake located near the transmission, so that all the braking effort is transmitted by the rear axle shaft to the wheels. We are quite safe in assuming a maximum load on each rear wheel of 8000 lb. and a coefficient of adhesion of the rubber tire to the road, of 0.6. The diameter of the wheels is 40 in., so that torque on shaft is 96,000 in.-lb. The writer does not believe that we really get this

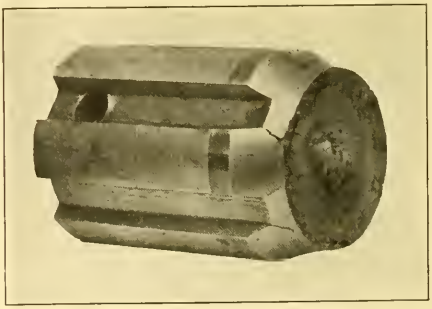


FIG. 4 EFFECT OF SPLINE

torque owing to the elastic rubber tires absorbing part of this blow; but assuming that it were obtained, we would have a maximum stress of 93,000 lb. per sq. in. set up in the axle from the formula

$$\text{Twisting moment or torque} = \frac{\pi f r^3}{2}$$

(It must be understood that the above loads are not normal working loads, but are the maximum that can be expected. It is obvious, therefore, that the shafts which have broken may have been considerably overstressed, although a large number of these actually ran high mileages up to 30,000 and 40,000 miles before breaking. For this reason, it was felt that a comparatively small increase in strength might be sufficient to prevent such breakages and a set of experiments was put in hand to determine the governing factors. The necessity for this lay in the fact that it was almost impossible to increase the diameter of the shafts, which was, of course, the obvious step to take.

A study of the fractures shown in Figs. 2 to 5 convinced us that the large splines were a very grave source of weakness. If each spline is considered as a small cantilever of breadth $2b$ jutting out from the shaft, with a load of $2W$ upon it, the bending moment at the junction will be $2Wb$; if we take double the number of splines, but keep the same total bearing area, each spline will have half its former breadth and carry half its former load and the bending moment will then be $\frac{Wb}{2}$, or only ¼ of the above. In addition to the gain in strength by this change, the diameter of the shaft at the bottom of the splines can be increased by the height of one spline, and yet keep the outside diameter the same. It was felt, also, that, as the strength should be calculated from the diameter at the bottom of the splines, it would be advisable to turn down the shaft in the middle and so reap the advantage of having it uniformly strong throughout its length, and avoid trouble due to sudden changes in torque-resisting values. This, therefore, gave a shaft (Fig. 9) with 12 splines and with effective diameter increased from 1.75 in. to 1.8965 in., representing an increase in strength of

$$\frac{1.9^3}{1.75^3} = \frac{6.86}{5.36} = 28 \text{ per cent approx.}$$

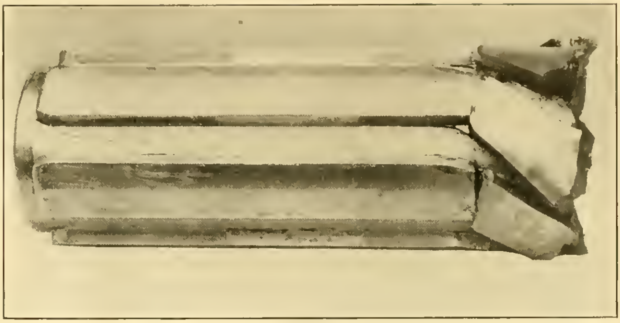


Fig. 5 Characteristic Fracture

The body of the shaft was ground and polished to avoid all scratches. It was found from examination of fractures that the slightest flaw was enough to start a breakdown. Particular attention was given to the junction of the main body of the shaft with the parts of larger diameter used for the splines, to avoid grooving of the filleting tool.

The designer naturally looks first to the manufacturing end as the cause of his troubles and one of the first investigations was to assure that the axle was subjected to pure torque and not a combined bending and twisting stress. Half a dozen complete axles, some of which had run up large mileage with no fracture, and the remainder had fractured in their early life, were inspected in detail; no difference was found, the only errors present being those that fell within what could only be considered as limits of tolerance. This disposed effectually of improvement being effected in machining process.

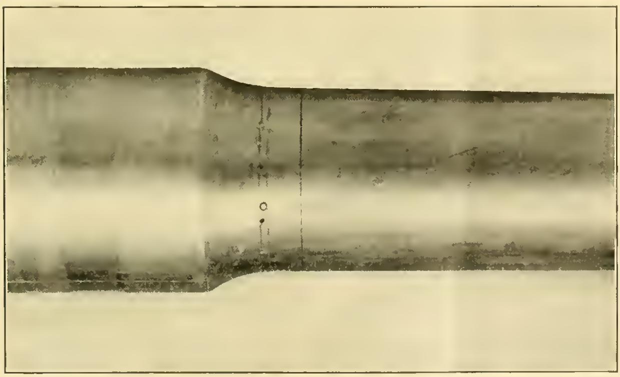


Fig. 6 Lines showing Planes of Cleavage in a Shaft about to Break

The other variables being disposed of, the question of material only remained. It had first been the impression that the best material available was being used, and certainly the first physical tests indicated a high grade of alloy steel. The writer had noticed the curious fact, however, that the energy required to fracture a piece of ordinary soft mild steel was practically the same as that required to fracture an exactly similar piece of high-grade alloy steel. Several tests which the writer has witnessed have even shown that a soft steel bar requires more energy to break it than does a hardened bar. The question, therefore, at once suggested itself: "Should the shaft be of a softer steel capable of twisting more under a suddenly applied load, and afterwards returning to normal conditions; or should it be of a very much harder steel, which would be more rigid and not deflect so much, but which would require a greater load to break?" The writer reasoned that if the elastic limit could be raised materially, the shafts would stand up better. Experiments made with small heat-treated specimens, which

could be bent by hand, indicated that this was on the right path and accordingly, after some experiments, two shafts were heat-treated to 175,000 lb. elastic limit (measured in the usual way), and tested on a truck in very severe service; these stood up.

Further tests showed the desirability of increasing the carbon content somewhat, and several shafts were made to the new specifications and sent out on hard service with excellent results. The material was a domestic steel of the following characteristics:

ened when hot, under a press. Each individual shaft is then put under the brinell hardness machine, and its brinell number read at the ends and the middle of the bar. This should be 402 to 444. It is then wrapped around with a metal tag, used with the idea of getting reliable results on the different steels we were trying out in our search for a suitable material. In this connection it is interesting to note that 5 per cent nickel steels, chrome vanadium steels, and air hardening steels were tried out and so far all have been standing up to service. The physical specifications of all these steels are very much alike. The success, therefore, seems due entirely to the higher elastic limit, especially as a number of these axles had six flutes and were not of the later 12-flute type.

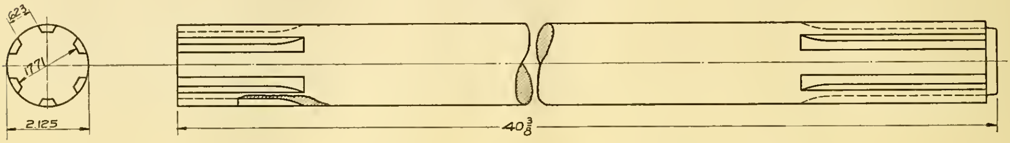



Fig. 7 The Original Shaft

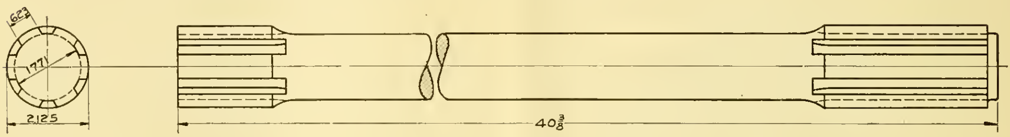



Fig. 8 Second Design of Shaft

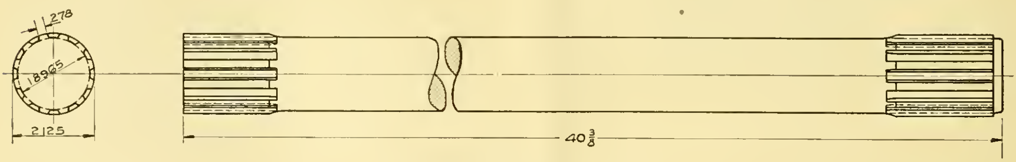



Fig. 9 Final Form of Shaft

| Chemical | Per cent |
|---|---|
| Carbon about | .30 |
| Manganese | .50 |
| Chromium | 1.5 |
| Nickel | 3.5 |

| Physical | Lb. per sq. in. |
|---|---|
| Elastic limit | 175,000 |
| Tensile strength | 185,000 |
| | Per cent |
| Elongation per cent in 2 in. | 14 |
| Reduction of area | 53 |

These experiments proved so satisfactory that in September, 1913, a number of these heat-treated shafts were sent out to replace others. Not one of these nor the original experimental shafts have broken, to the best of the writer's knowledge.

The shafts are machined from hot-rolled bars already heat-treated to show an elastic limit of about 100,000 lb. They are then heated in a gas furnace to a temperature of between 1450 and 1500 deg. fahr., and quenched in oil. (This double treatment is to insure the grain being properly refined.) They are then reheated to a little over 700 deg. fahr., and allowed to cool slowly in the air.

Some trouble was experienced at first with warping, but slight experimenting showed they could be readily straightened when hot, under a press.

As a secondary result of the investigations it was thus definitely established that under pure torsional conditions the strength of a shaft is increased by increasing its elastic limit by heat treatment. It would naturally follow, therefore, that similar results could be expected from other components under tensile or shear stress, and accordingly greater attention has been paid to heat treating. The elastic limit has been raised in many pieces with corresponding advantage and, in addition, as a special measure of precaution, each important structural forging or bar is submitted to test on either the scleroscope or the brinell machine to insure that the piece has been properly treated. Both these machines give very reliable readings which can be directly compared with the elastic limit, and by their use a number of forgings seemingly all right, but actually either too hard or too soft, have been detected.

As regards the economic aspect of the use of heat-treated steels, it is found that this process costs between 2 and 2½

cents per lb. and as the strength can in many cases be nearly doubled it clearly effects a large saving. Alloy steels, properly heat treated, are indispensable for motor truck work, as their capacity to resist fatigue is very great. The writer looks forward to their extended use among other mechanical engineers, just as the ball bearing first introduced for cycle and automobile work is now becoming a universal friction saver. As a permanent repair the heat-treated piece of steel is in many cases worth its weight in gold.

## DISCUSSION

H. Wade Hibbard said that, as a member of the Jury of Awards in San Francisco in the Bureau of Engineering, he made use of his privilege to inquire from many of the exhibitors regarding the use in power machinery of heat-treated alloy steels, and confessed that it was a disappointment to find how little it was being used.

He would ask the author to tell in his closure what he means by "elastic limit?" Is it the commercial elastic limit or drop of the beam; or is it a more scientific elastic limit obtained by means of an extensometer, electric contact or otherwise?

With reference to the strains which occur in connection with the reversal of loads, there are Wöhler's experiments and the experiments of those who have followed Wöhler, accounts of which are to be found in any good book on machine design.

Cornelius T. Myers[1] (written). Mr. Younger has treated his subject with characteristic thoroughness and the conclusions set forth, I believe, are worthy of more than mental note by those members of the Society to whom the matter is at all pertinent. The strides made by the automobile industry, comparatively a youngster among the industries of the nation, have not been accomplished without much careful application of mechanical and metallurgical engineering. Analogous problems confront us in the older branches of industry and the suggestions that can be gotten from even a cursory study of the methods in vogue in automobiledom should be well worth while.

Radcliffe Furness[2] (written). I should like to point out that by increasing the carbon in the material the author increased the true elastic limit and, therefore, the proportion between this and the yield point, thus having a much greater factor of safety in the higher carbon material than existed in the low carbon material.

The two points which are brought forcibly to my mind by Mr. Younger's paper are: First, the desirability of an engineer making a thorough and careful study of the physical properties of the metal which he has in mind to use, in conjunction with the work that he expects this metal to perform, the test conditions being exactly similar to the actual conditions. This has been done by the author in his paper, to my mind, in a most thorough manner.

Secondly, Mr. Younger mentions that alloy steels properly heat-treated are indispensable to motor truck work. Since this is so, it immediately comes to the mind of anyone familiar with metallurgy that the converse is true: namely, that alloy steels improperly heat-treated are actually a menace to all work where they are used and, in addition, should never be used when not given a known and thoroughly tried heat treatment.

In the fabrication of any steel forging, one is obliged to heat the steel above the critical temperature, which is the temperature at which remarkable changes take place in the molecular arrangement. Since the final physical properties depend upon the rate at which the steel cools through the critical range, the number of degrees heated above the critical range, or the time that it has been held at the temperature

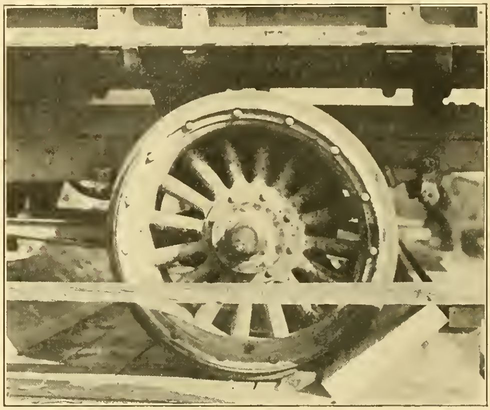


Fig. 10 "Cradle" in which Truck was Surged to and fro by its own Power

above the critical range when forgings are being manufactured, one can readily see that forgings are subjected to heat treatment in the process of fabrication.

Alloys are added to steel because they emphasize the changes that can be brought about by heat treatment in the molecular arrangement and thus increase the physical properties that can be obtained from the material in hand. Thus, by the addition of alloys, one is emphasizing the difference that can be obtained by varying heat treatments. If the forgings are given no definite heat treatment and are being turned out at different rates, they will be subjected to varying heat treatments and, although it is possible in fabrication to turn out an article which has all the properties of a piece that has been put through a carefully thought-out and prescribed heat treatment, the likelihood of accomplishing this, when the chances of producing other results are infinite, is so small as to be negligible. In addition, one would have many forgings of varying physical properties from the varying heat treatments which they of necessity receive. It becomes necessary, therefore, to treat the material to bring it to a known standard; and, since one has increased the susceptibility by addition of alloys, it is evidently more necessary to heat-treat alloy steels than in the case of simple carbon steels.

It is the duty of all who are interested in the success of alloy steels to emphasize on all occasions the desirability of putting the steels into the condition which will give the best possible results, and of removing the common but fast dying

[1] Engineer, The Timken-David Brown Co., Detroit, Mich.

[2] Midvale Steel Co., Philadelphia, Pa.

impression that a steel, because it is a nickel, nickel-chrome or chrome-vanadium steel, is better than a plain carbon steel, no matter what heat treatment it may have received, when as a matter of fact the contrary is really true.

The Author: In reply to Mr. Furness as to the probability of a mistake in heat-treated alloy steels, one method of guarding against this is to subject each individual forging to either a brinell test or a scleroscopic test.

Forgings of alloy steel are expensive and the author believes that it is just as necessary to inspect them for the heat treatment as it is to put the gage or a rule alongside of them to find out if they measure correctly. For that reason, therefore, he has an inspection put on each forging consisting of either a scleroscope test or a brinell test in order to insure that the heat treatment has been properly carried out. It is found these two tests give a very good indication of the state of the metal.

With regard to Professor Hibbard's question, the elastic limit of 175,000 lb. is by drop of beam,—the ordinary commercial elastic limit. The extensometer tests show a slightly lower elastic limit. From observation of tests of the axles and from breaking pieces of steel, the author feels that the real elastic limit is lower than that obtained by the drop of the beam. For this reason, many of the axles broke under conditions where they ran perhaps 8,000 to 15,000 miles. It is known that the first calculations were very nearly right, taking into account what might be called a normal elastic limit.

The author once made a test on a truck, driving down town with a pendulum bob in front of him, which was really a rough accelerometer. As the truck accelerated forward, the pendulum bob of course swung backwards and everything seemed to act quite normally until a policeman raised his hand and stopped the machine and then gave a signal to go across the street. The truck then accelerated forward, when suddenly a small machine ran out in front; the brakes were jammed on and the pendulum bob swung right across from backwards to forwards. Several tests were tried after that and the conclusion was reached that the stress on material subject to alternating stresses is not the stress based on what might be called the normal line, but is the summation of the two stresses, and the elastic limit based on this summation should be very much lower, how much lower he did not know exactly. Roughly speaking, the elastic limit is anything from about one-half to two-thirds of what it is thought to be.

Tests made on testing machines appear to be of exceedingly little value. This is perhaps rather a hard thing to say, but it it true, and it is no use making tests on a few specimens of meagre size when the material breaks down when it comes to the practical use of large quantities of full size. The author has come to the conclusion that the practical test is the only real test. All the theoretical tests, the Sankey bending machine tests, the Avery impact tests and the ordinary tensile tests show this high tensile steel actually was not as satisfactory as what engineers call tough material, that is, material of a lower elastic limit, with a higher elongation and higher contraction.

We are still trying to find laboratory machines which will tell us what stresses we actually get in trucks, but we haven't got them yet.

# A COMPARISON OF THE PROPERTIES OF A NICKEL, CARBON AND MANGANESE STEEL BEFORE AND AFTER HEAT TREATMENT

BY ROBERT R. ABBOTT, CLEVELAND, O.

Non-Member[1]

THE effect of small quantities of manganese upon the physical properties of annealed steel is fairly well known. Up to about 2 per cent, each 0.01 per cent of manganese increases the tensile strength by about 160 lb. per sq. in. Its effect upon the reduction in area and elongation is very small, slightly increasing the former and lowering the latter. From about 2½ to 7 per cent manganese makes steel extremely brittle, and above 7 per cent this effect disappears and we again have a useful alloy. An 11 per cent alloy has a wide range of use in the cast form for crossing frogs, rolls, gears, etc.; it is usually finished by grinding, as it is nearly impossible to machine.

We can classify the average commercial steels made in this country with carbon less than 0.50 per cent into those with manganese contents approximately (*a*) 0.40 to 0.50 per cent; this group includes the ordinary carbon steel and chrome-nickel steel, (*b*) 0.60 to 0.70 per cent; this group includes nickel and chrome-vanadium steels. This classification represents fairly well commercial practice; English steels fall readily into it, but with German steels the grouping is not so well defined. It is rare to find a steel in this country with manganese above 1 per cent (and below 2 per cent). Abroad, a considerable amount of steel is used, particularly for frames of automobiles, with manganese varying from 1.25 to 1.75 per cent.

Very little has been published regarding the heat treatment of these high manganese steels, and I am therefore presenting a comparison of the effect produced upon the physical properties of three steels of about the same carbon contents. One of these is a plain carbon steel, another a nickel steel, and the third a manganese steel, containing 1.61 per cent manganese. Their analysis is as follows:

| | Carbon steel | Nickel steel | Manganese steel |
|---|---|---|---|
| Carbon | 0.342 | 0.336 | 0.341 |
| Phosphorus | 0.014 | 0.019 | 0.047 |
| Sulphur | 0.029 | 0.019 | 0.025 |
| Manganese | 0.54 | 0.55 | 1.61 |
| Silicon | 0.030 | 0.188 | 0.009 |
| Nickel | 0.0 | 3.17 | 0.0 |
| Chromium | 0.0 | 0.0 | 0.0 |
| Vanadium | 0.0 | 0.0 | 0.0 |
| Copper | 0.0 | 0.05 | 0.02 |

In these three steels the upper critical temperatures were first determined. Test bars ¾ in. in diameter and 4½ in. long were next machined from each steel; one of each kind was annealed by heating in lead to a temperature 5 deg. fahr. above the upper critical temperature, holding there

[1] Metallurgical Engineer, The Peerless Motor Car Co.

Presented at the Spring Meeting of the Society, June 1915. Complete paper may be obtained without discussion; price 5 cents to members; 10 cents to non-members.

about ten minutes, and allowing to cool slowly until the lead solidified. The time of this cooling was about ten hours. The lead was then heated slowly to a temperature of 800 deg. fahr. and the test bars removed. They were then threaded and machined to a standard 2 in. test specimen and ground to a diameter of 0.505 in. (1/5 sq. in.). One end was left longer than the other to allow for hardness tests. They were then pulled in a tensile machine with the following results:

| Steel | Elastic | Maximum | Reduction | Elongation | Brinell hardness |
|---|---|---|---|---|---|
| Carbon | 36,600 | 67,250 | 51.0 | 32.0 | 120 |
| Nickel | 55,000 | 81,850 | 59.0 | 31.2 | 153 |
| Manganese | 61,150 | 87,850 | 58.5 | 29.9 | 150 |

From these figures we see that the manganese steel is slightly stronger than the nickel steel, and has practically the same amount of "toughness" as shown by the reduction in area.

For the heat-treated specimens a test bar of the same size was used. The heating was all done in lead and was

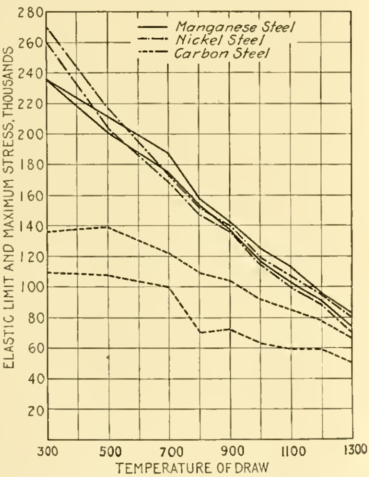



FIG. 1 TESTS ON EFFECT OF HEAT TREATMENT ON MAXIMUM STRESS [UPPER CURVES] AND ELASTIC LIMIT [LOWER CURVES]

controlled by a Leeds & Northrup resistance pyrometer. The desired temperature was reached slowly and maintained as nearly constant as possible for ten minutes. All tests which were to be made at the same temperature were made simultaneously. The furnace contained half a ton of lead, and therefore the temperature could be kept very uniform. The bars were quenched in water and were drawn to the desired temperature in a lead furnace holding about three tons, all bars to be drawn at the same temperature being drawn simultaneously. The desired temperature was maintained constant for thirty minutes.

After treatment the bars were machined, ground to a diameter of 0.505 in., and pulled in a tensile machine having an autographic recording device. Hardness tests were made on the long end of the test bar after sawing off and grinding to a flat surface. The following determinations were made: elastic limit; maximum strength; reduction in area; elongation; brinell hardness; scleroscope hardness; rupture stress; energy in foot pounds necessary to cause fracture. The last three determinations are not considered here. Test bars were treated from above the upper critical temperature and were then drawn to the following temperatures: 300, 500, 700, 800, 900, 1000, 1200, 1300 deg. fahr.

In Figs. 1, 2 and 3 are plotted the results of these tests

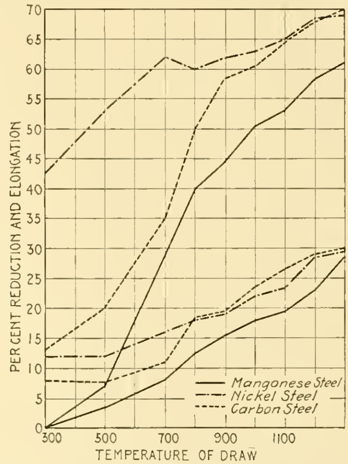



FIG. 2 TESTS ON EFFECT OF HEAT TREATMENT ON REDUCTION IN AREA [UPPER CURVES] AND ELONGATION [LOWER CURVES]

for the three steels. From these charts it can be concluded that practically the same results can be obtained, as far as strength is concerned, by the heat treatment of a 1.6 per cent manganese steel as for a nickel steel of practically twice the per cent of nickel. However, since the nickel steel also contains 0.55 per cent manganese, we actually have an excess of only 1.06 per cent manganese, which apparently has the same effect as about three times the same amount of nickel.

Now, regarding the "toughness," which for the sake of comparison can be considered as being measured by the reduction in area, we see that the manganese steel does not compare so favorably with the carbon or nickel steel for the same temperature of draw. Evidently also, while manganese increases the reduction in area in annealed steels, it has the opposite effect in heat-treated steels.

The next determination was upon the effect of over- and under-heating during the quenching process. For this purpose ten bars of each steel were quenched as follows: One 5 deg. above the upper critical point, six others at 25, 50, 75, 100, 125 and 150 deg. above and three at 25, 50 and 75 deg. below the critical point. These were all drawn to a temperature of 800 deg. fahr. and the regular tests conducted upon them. The results of these tests are plotted in Figs. 4 and 5. They show that there is very little difference between the nickel and manganese steels as far as over and under heating is concerned.

Summarizing, for a heat-treated $1\frac{1}{2}$ per cent manganese steel the manganese in excess of that contained in a nickel

steel of a corresponding carbon contents (about 0.34 per cent) exerts a strengthening effect equivalent to about three times the same amount of nickel. While the manganese

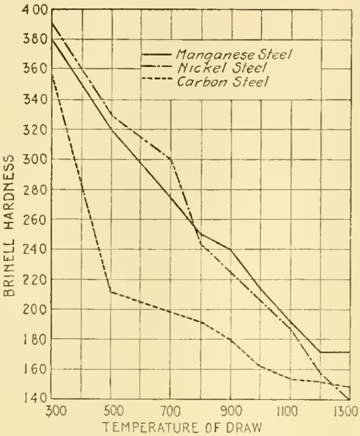



Fig. 3 Tests on Effect of Heat Treatment on Brinell Hardness

effect upon a steel which has not been heat-treated is to increase the toughness slightly, its effect upon a heat-treated steel is decidedly the reverse; in the case of nickel, the effect upon an untreated steel is practically zero, while in a heat treated steel nickel increases the toughness decidedly. An untreated steel containing about 1½ per cent manganese is fully as tough as and is stronger than a nickel steel of about 3¼ per cent nickel.

The following equations represent fairly well the average

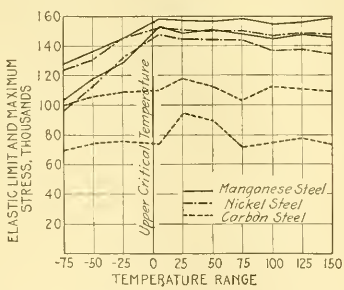



Fig. 4 Tests on Effect of Over- and Under-heating on Maximum Stress [Upper Curves] and Elastic Limit [Lower Curves]

values of the elastic limits, maximum strengths, reduction in area and elongation of the three steels.

$E$ = elastic limit in pounds per square inch.

$M$ = maximum stress in pounds per square inch.

$r$ = reduction in area in per cent.

$e$ = elongation in per cent.

$T$ = temperature of draw in fahrenheit.

For manganese steel

$$E = 284{,}000 - 163\,T$$
$$M = 288{,}000 - 159\,T$$
$$r = -19 + .068\,T$$
$$e = -10 + .028\,T$$

For nickel steel

$$E = 302{,}000 - 183\,T$$
$$M = 314{,}000 - 188\,T$$
$$r = 40 + .024\,T$$
$$e = 3.5 + .018\,T$$

For carbon steel

$$E = 134{,}000 - 66\,T$$
$$M = 170{,}000 - 77\,T$$
$$r = -5.8 + .063\,T$$
$$e = -3 + .026\,T$$

## DISCUSSION

Henry M. Howe[1] (written): The manganese steel to which Mr. Abbott calls attention has come into use in this country more widely than might be inferred from his remarks. The late Maunsell White developed a steel of over

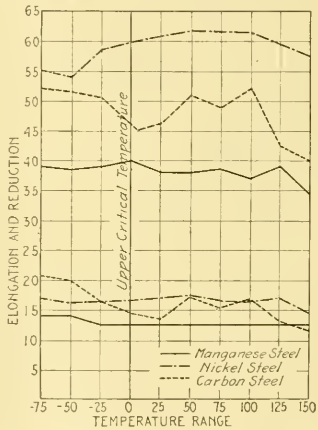



Fig. 5 Tests on Effect of Over- and Under-heating on Reduction in Area [Upper Curves] and Elongation [Lower Curves]

1 per cent. manganese and somewhat lower in carbon than Mr. Abbott's, and this has gone into very wide use where high quality is needed.

Roughly speaking, 1 per cent of manganese is about equivalent to 2 per cent of nickel, at least 1 per cent of manganese accomplishes some of the more important things which double the quantity of nickel accomplishes.

The reason why manganese and nickel are useful for such steels is a very simple one. In order to develop the properties of a given steel very highly it should be heated above the transformation range, in order to cause the usual rather coarse masses of ferrite to become reabsorbed. The steel should then be cooled rapidly, lest in slow cooling through the transformation range the ferrite again should form coarse masses.

If this cooling is done by quenching in water or oil the resultant steel is too brittle; that is to say, the chemical trans-

[1] Columbia University, New York.

formation is arrested and at the same time serious internal stresses are set up. In order to permit the transformation to complete itself, so that the chemical brittleness may be removed, and in order to relieve the stresses which are also a cause of brittleness, the steel must next be reheated, as in tempering or moderate annealing. The rise of temperature enables the chemical transformation to complete itself, so that the metal becomes transformed into ferrite and cementite. It also releases the stresses. But this is accompanied by an incidental damage, namely that the resultant ferrite coalesces more and more into larger and larger masses, and with the increase in the size of these masses the quality of the steel falls off progressively.

The advantage of manganese and nickel is that they cause this coalescence and coarsening to occur very slowly. As a consequence, when the steel is reheated so that the transformation occurs, removing the chemical brittleness, and that the stresses are removed, thus removing the second cause of brittleness, the coalescence of the ferrite is very much slower than in steel with less manganese.

And in general this same sluggardizing effect of manganese and nickel under miscellaneous conditions gives rise to a finer structure than would otherwise form. Their effect in this respect is like that of vanadium, only less powerful.

## ON MEASURING GAS WEIGHTS

BY THOMAS E. BUTTERFIELD, SOUTH BETHLEHEM, PA.

Member of the Society

The author is interested in accurate methods of determining gas quantities, such as the quantity of gas delivered by a fan, a blower, or a compressor, or the quantity of gas generated by a producer, furnace or other combustion apparatus, or finally the quantity of gas used or consumed for various purposes.

In reporting results on gas measurement, the use of volume as an expression of quantity or mass should be eliminated. Gas quantities should be expressed by weight. Volumes of ordinary standard gases even at standard pressure and temperature are useful in determining quantities, but it is almost always misleading to use such volumes as measures of quantity or mass.

The name of a gas even to the engineer is no exact indication of its constitution or physical properties, because commercial gases made by the same process or indeed in the same apparatus are subject to important variations in the proportions of their principal constituents.

Density of a gas may be readily calculated from the chemical analysis, but the result of such calculation giving quantity in pounds should always be reported by the investigator. For fuel gases this would also imply that thermal quality be expressed in heat units per pound, and in general all volume data should be regarded as of only collateral interest.

It is usual to consider that after generation commercial gases retain their composition unaltered. Even gases containing no condensible tarry constituents, however, suffer considerable changes in their moisture content with changing temperature, due to the corresponding change of vapor tension of steam. If a gas be used at the same temperature with different treatment after water contact or with no water contact, the moisture content will be quite different. The ordinary volumetric analysis gives the composition of the dry gas, which is different from the actual composition as generated or used.

Where accuracy is of importance the moisture content should be measured.

Gasometer measurements furnish the most accurate method of determining gas volumes and weights. It is essential that the temperature of the gas should be uniform in every part of the gasometer.

Displacement gas meters, whether of wet or dry type, are very accurate where the volume of the measuring chamber is unalterable or accurately known at every instant, and where the pressure, temperature and humidity of the gas at the instant of filling are also known, or nearly the same as at calibration. This is not true in fluctuating flow.

The pitot tube, venturi meter, and orifice methods of measurement depend for accuracy on the preservation of a constant relation of velocities over an entire cross-section, accurate measure of this cross-section, and accurate measurement of gas density. It is evidently as easy to calculate weights as volumes from the readings of such meters. They are not at all adapted to measure a rapidly fluctuating flow or a flow accompanied by eddies.

Where the specific heat of the gas is known its weight may be calculated by the change in temperature produced by the addition or abstraction of a known quantity of heat.

Where large volumes of gas are to be measured reliable shunt methods could be developed for measuring part of the flow, just as electric current is measured. A rational form for such a shunt would be a double walled diaphragm placed in the main through which the gas passes. The diaphragm is pierced full of holes all of the same size, say of about one inch diameter. From one in twenty to one in one hundred of these holes communicates with the interior of the diaphragm, the remainder pass through both walls, and are short, slightly flaring tubes with sharp edges. The gas from the interior of the diaphragm is carefully metered and returned to the main, and gives a measure of the total amount flowing. This method should give quite accurate results with either continuous or fluctuating flow.

Finally, we have methods which depend on chemical analysis of the gas and measurement of one constituent which forms a known percentage of the whole.

Various metallurgical formulae' are in use for obtaining the result from volumetric analyses of fuel and burnt gas. It is the author's belief that the following method, based on reduction of volumetric analysis to weight analysis is simpler and safer than other methods, and the principal object of this paper is to urge its adoption in a standard code.

An example will illustrate the method. The fuel gas contains 2 per cent moisture. The volumetric analysis of dry fuel gas is $CO = 6$ per cent, $CO_2 = 2$ per cent, $CH_4 = 40$ per cent, $C_2H_4 = 4$ per cent, $H_2 = 46$ per cent, and $N_2 = 2$ per cent. After burning with air containing $1\frac{1}{2}$ per cent moisture the volumetric analysis of the dry products of combustion is

$CO_2 = 8.8$ per cent, $O_2 = 4.5$ per cent, and $N_2 = 86.7$ per cent.

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It is required to find the ratio by weight or volume of the burnt gas to fuel gas. Call this ratio $a_w$ for weight, or $a_v$ for volume. Then, necessarily, the weight of air is $a_w - 1$, if fuel gas weight be taken as unity.

The four elements, carbon, hydrogen, oxygen and nitrogen are the only ones present in the three gases, and the volumetric analyses are reduced to weight analyses giving proportions of these four elements. The actual volumetric analysis of the fuel gas including moisture is

| Constituents | $CO$ | $CO_2$ | $CH_4$ | $C_2H_4$ | $H_2$ | $N_2$ | $H_2O$ |
|---|---|---|---|---|---|---|---|
| Per cent | 5.9 | 2 | 39.2 | 3.9 | 45 | 2 | 2 |

The total carbon weight is

$$12\,(5.9 + 2 + 39.2 + 2 \times 3.9) = 659.$$

The hydrogen weight is

$$1\,(4 \times 39.2 + 4 \times 3.9 + 2 \times 45 + 2 \times 2) = 268.$$

The oxygen weight is

$$16\,(5.9 + 2 \times 2 + 2) = 190.$$

The nitrogen weight is

$$28 \times 2 = 56.$$

The density of the gas is

$$\frac{659 + 268 + 190 + 56}{200} = \frac{1173}{200} = 5.86 \text{ times that of hydrogen.}$$

The weight analysis by elements is: carbon $= \frac{659}{1173}$, hydrogen $= \frac{268}{1173}$, oxygen $= \frac{190}{1173}$ and nitrogen $= \frac{56}{1173}$, or in per cent $C_1 = 56.1$ per cent, $H_1 = 22.9$ per cent, $O_1 = 16.2$ per cent, and $N_1 = 4.8$ per cent, using the subscript "one" to denote fuel.[1]

Similarly the weight analysis of air is: $H_2 = 0.1$ per cent, $O_2 = 24$ per cent, and $N_2 = 75.9$ per cent, with a density $= 14.34$ times that of hydrogen. We use subscript "two" to denote air.

The weight analysis of the "dry" products of combustion is: $C_{30} = 3.6$ per cent, $O_{30} = 14.4$ per cent, $N_{30} = 82$ per cent and the density is 14.8 times that of hydrogen. We use subscript "30" to denote "dry" products of combustion.

The weight of any element in the burnt gas (before condensation of moisture) is the sum of the weights in fuel gas and air, giving rise to the four fundamental equations:

$$C_1 + (a_w - 1)\,C_2 = a_w\,C_3, \text{ carbon equation} \quad \ldots\ldots\ldots\ldots [1]$$

$$H_1 + (a_w - 1)\,H_2 = a_w\,H_3, \text{ hydrogen equation} \quad \ldots\ldots\ldots [2]$$

$$O_1 + (a_w - 1)\,O_2 = a_w\,O_3, \text{ oxygen equation} \quad \ldots\ldots\ldots\ldots [3]$$

$$N_1 + (a_w - 1)\,N_2 = a_w\,N_3, \text{ nitrogen equation} \quad \ldots\ldots\ldots\ldots [4]$$

Since the weight of carbon in air is negligible

$$C_1 = a_w C_3 \text{ or } a_w = \frac{C_1}{C_3} \quad \ldots\ldots\ldots\ldots\ldots\ldots [5]$$

Since the relative proportions of carbon and nitrogen in the burnt gas cannot be altered by the separation of moisture, we may write

$$\frac{\text{carbon in fuel plus carbon in air}}{\text{nitrogen in fuel plus nitrogen in air}} = \frac{\text{carbon in dry burnt gas}}{\text{nitrogen in dry burnt gas}}$$

or

$$\frac{C_1 + (a_w - 1)\,C_2}{N_1 + (a_w - 1)\,N_2} = \frac{a_w C_3}{a_w N_3} = \frac{a_w C_{30}}{a_w N_{30}}$$

Simplifying

$$\frac{C_1}{N_1 + (a_w - 1)\,N_2} = \frac{C_{30}}{N_{30}}, \text{ and } a_w = 1 + \frac{C_1 N_{30} - N_1 C_{30}}{N_2 C_{30}} \quad \ldots [6]$$

Equation [6] gives a simple expression for the weight ratio from the analyses by weight of fuel and "dry" burnt gas. The weight of moisture in the burnt gas is nine times the total weight of hydrogen in fuel and air, or

$$9\,\{H_1 + (a_w - 1)\,H_2\}$$

and the weight of "dry" burnt gas per pound of fuel is

$$a_w - 9\,\{H_1 + (a_w - 1)\,H_2\}.$$

Then

$$\frac{C_3}{C_{30}} = \frac{N_3}{N_{30}} = \frac{a_w - 9\{H_1 + (a_w - 1)\,H_2\}}{a_w}$$

and

$$C_1 = a_w C_3 = [a_w - 9\{H_1 + (a_w - 1)\,H_2\}]C_{30} \text{ and } a_w = \frac{C_1 + 9(H_1 - H_2)C_{30}}{(1 - 9\,H_2)C_{30}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [5a[$$

Similarly for nitrogen

$$N_1 + (a_w - 1)N_2 = [a_w - 9\{H_1 + (a_w - 1)\,H_2\}]N_{30} \text{ and}$$

$$a_w = \frac{N_2 - N_1 - 9(H_1 - H_2)\,N_{30}}{N_2 - N_{30}(1 - 9\,H_2)} \quad [4a]$$

The oxygen in air and fuel less the oxygen that separates from the burnt gas as moisture is equal to the oxygen in the "dry" burnt gas, or

$$O_1 + (a_w - 1)\,O_2 - 8\{H_1 + (a_w - 1)\,H_2\}$$
$$= [a_w - 9\{H_1 + (a_w T - 1)\,H_2\}]O_{30}$$

or

$$a_w = \frac{O_2 - O_1 + (8 - 9\,O_{30})\,(H_1 - H_2)}{O_2 - 8\,H_2 - O_{30}\,(1 - 9\,H)_2} \quad \ldots\ldots\ldots\ldots [3a]$$

Applying equations [3a], [4a], [5a] and [6] to the solution of the problem given we use the recapitulation of analyses by weight.

| | Fuel | Air | Dry burnt gas |
|---|---|---|---|
| O | 16.2 | 24 | 14.4 |
| N | 4.8 | 75.9 | 82 |
| H | 22.9 | 0.1 | .... |
| C | 56.1 | .... | 3.6 |
| Density | 5.86 | 14.34 | 14.8 |

Then from [3a]

$$a_w = \frac{O_2 - O_1 + (8 - 9\,O_{30})\,(H_1 - H_2)}{O_2 - 8\,H_2 - O_{30}\,(1 - 9\,H_2)} = \frac{0.24 - 0.162 + (8 - 9 \times 0.144)\,(0.229 - 0.001)}{0.24 - 8 \times 0.001 - 0.144\,(1 - 9 \times 0.001)} = 18.05$$

From [4a]

$$a_w = \frac{N_2 - N_1 - 9\,(H_1 - H_2)\,N_{30}}{N_2 - N_{30}\,(1 - 9\,H_2)} = \frac{0.759 - 0.048 - 9\,(0.229 - 0.001)\,0.82}{0.759 - 0.82\,(1 - 9 \times 0.001)} = 18.13$$

From [5a]

$$a_w = \frac{C_1 + 9(H_1 - H_2)C_{30}}{(1 - 9\,H_2)\,C_{30}} = \frac{0.561 + 9(0.229 - 0.001)0.036}{(1 - 9 \times 0.001)0.036} = 17.79$$

From [6]

$$a_w = \frac{C_1 N_{30} - N_1 C_{30}}{N_2 C_{30}} = 1 + \frac{0.561 \times 0.82 - 0.048 \times 0.036}{0.759 \times 0.036} = 17.79$$

The percentage error $\frac{18.13 - 17.79}{18.13} \times 100 = 1.9$. The error evidently lies in the too rough approximation in de-

[1] In the equations which follow, the numerical subscripts do not indicate numbers of atoms.

termining $C_{30} = 0.036$. The value of the check given by the separate determinations is evident. The author has had this method in use for some years with very satisfactory results.

The author has been requested to give reasons why gas quantities should be expressed in weight rather than by volume. There are two very important reasons.

*First.* If gas quantity is expressed in pounds we have the simplest possible unit. Erroneous statements of weight will not often be made and are easily checked. On the other hand, if quantities are expressed by volume, we must give volume, temperature and pressure both under observed conditions and reduced to some standard pressure and temperature. There is considerable probability of errors in neglecting or forgetting to reduce volume to standard conditions, or in neglecting to state the conditions assumed standard. Further, weight makes an immensely stronger appeal to the senses than volume. This in itself makes it harder for the writer to make errors and easier for the reader to detect errors and comprehend results.

*Second.* The value of a definite gas in the various industries is determined by its weight rather than by its volume. For instance, in furnace work, it is necessary to furnish a certain weight of air to consume the fuel. In measuring the output of a compressor, it is important to know the number of pounds of air delivered against the discharge pressure. The capacity of an air pump is determined by the number of pounds of air it can remove from a certain vacuum. The capacity of a gas engine is determined by the number of pounds of air and fuel it can draw into the cylinder. In all of these cases the volume is of subordinate interest. Comparison on the basis of volumes is misleading

In a combustion process involving solids or liquids and gases the custom of giving fuel quantities in pounds and air and gas quantities in cubic feet is not conducive to clear thinking. Imagine an investigator stating that a certain number of cubic feet of coal was charged into a furnace! Of course weight of gas cannot be determined ordinarily without calculation. But the calculation involved is not greater than that required to put volume readings in form permitting definite and precise understanding of results.

In reference to the illustrative example given, the author wishes to state that, in his method of calculating the weights of air and burnt gas from a known fuel weight, simple weight calculations are used and combustion formulæ are not used. This is the distinguishing feature of the method. The number of pounds of any element entering a reaction must be the same as the weight leaving. Equations 1 to 4, contain all the fundamental equations, following which the modifications required are shown when the complete analysis of burnt gas, including moisture, is not known. When weight ratio is known, as air, volume ratio can be easily found by dividing by density ratio.

## DISCUSSION

Arthur M. Greene, Jr., suggested that if the equations or methods given by the author were to be adopted, it would be better if the nomenclature were changed so that the literal values were more suggestive of the things for which they actually stood. One of the great faults in connection with equations is that literal values are so formed as to suggest something entirely different from the things for which they stand.

# THE USE OF CORRUGATED FURNACES FOR VERTICAL FIRE TUBE BOILERS

BY F. W. DEAN, BOSTON, MASS.

Member of the Society

I HAVE been impressed for many years with the value of corrugated furnaces for vertical boilers, but only recently have actually used them. By their use staybolts are

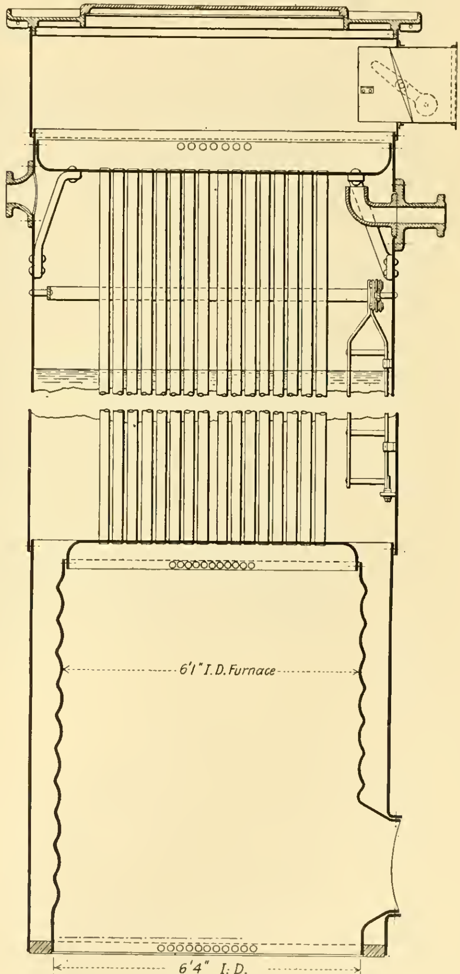


Fig. 1 Vertical Boiler with Corrugated Furnace

done away with, and as there appear to be no disadvantages in the furnace this is a most important feature. As many hundreds of staybolts are avoided in each boiler, there are

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just so many less opportunities for breakage and needed repairs.

This type provides for expansion and contraction of the tubes in a safe manner, but on account of its somewhat flexible character it should be assumed that it is advisable to support the lower tube plate as near the edge as practicable. The ordinary firebox is rigid vertically and supports the edge of the lower tube plate, but as the corrugated firebox has slight elasticity it is best to hold up as much of the tube plate as practicable by the tubes and provide little or no elasticity in the tube plates. The flat and unstayed portions of the upper and lower tube plates should be made equal in diameter in order to balance.

The behavior of the firebox end of the boiler when under pressure led to some speculation, for the area of the fire door opening theoretically unbalances it. When under hydrostatic pressure, various gauges were used for showing distortion, but none could be discovered.

In regard to sizes of such furnaces the catalogue of the American maker gives 60 in. as the maximum inside diameter, but in fact this company can make them up to 72 in., and almost 1 in. thick. They have been made slightly larger in Germany and the furnace of the boiler illustrated was obtained in that country. If the inside diameter is 72 in., the grate will be 3 in. larger or 75 in. and the grate area 30.68 sq. ft. It is easy enough to generate 200 h.p. on a grate of this size with considerable capacity for forcing beyond this, and there is no difficulty in providing the heating surface for this horsepower.

In regard to pressure, a furnace 72 in. in diameter and 0.95 in. thick will carry 200 lb. If there were sufficient demand for larger furnaces they would probably be forthcoming. The theory of heat transmission through plates, and experience, show that thick furnaces, especially if without riveted joints, are unobjectionable.

The introduction of corrugated furnaces for the fireboxes of the vertical type of boiler is, I think, a real improvement in steam boilers. The type possesses the important qualities of giving maximum and permanent economy, superheating the steam from 20 deg. to 40 deg., being free from brickwork and requiring small floor space per horsepower.

## DISCUSSION

W. F. MacGregor (written). In contemplating a change in any well known type of construction, it is natural to consider first the effect on that portion which experience has shown to have given the most trouble. This in vertical fire-tube boilers is tube leakage at the crown sheet. Our first question is, then, Will a flexible furnace tend to increase or diminish tube leakage, granting that the corrugated furnace is more flexible?

When the first Manning boilers were built, it was thought necessary to provide for the differential expansion between the tubes and shell, and an attempt was made to do so in the O. G. ring, but it was found to be impracticable. The amount of differential expansion cannot be great, and it is questionable if the tubes acting through the medium of the flexible crown sheet can produce a change in length of the corrugated furnace. On the other hand, it is possible to imagine that the corrugated furnace may gradually change in length and tend to produce tube leakage. As to whether the tube leakage will be greater or less with a corrugated furnace can only be shown by experience.

But the principal point in considering any new boiler construction is safety. Before abandoning the stay-bolted construction for other types we should bear in mind its good points as well as the bad ones. The stay-bolted surface is increased in strength by a slight deformation or bulging of the plates, while the corrugated furnace is weakened by any deformation, especially if local in character. Leakage at stay-bolts or a slight bulging of the plates, is sometimes a "blessing in disguise," in giving warning of conditions in the boiler that should be corrected in good time to avoid serious damage or disaster. Broken stay-bolts in stationary boilers are so common as to condemn this type of construction, but when provided with tell-tale holes they do not constitute a source of danger.

After considering safety, durability, efficiency and convenience, we must also take into account the cost of construction, and while the figures showing the cost of the corrugated furnace are not at hand, I believe it is more expensive than the other type. The most apparent advantages of the corrugated furnace in the vertical fire-tube boiler are the decreased resistance to circulation and the increased facilities for cleaning.

H. Wade Hibbard objected to the staying of the top tube sheet of the boiler shown in the figure. He referred to the statements of the author that this particular boiler will carry 300 lb. pressure and that the steam is superheated to as high as 40 deg. superheat. The temperature at the top of the diagonal stay for the tube top-sheet must be very much higher than the temperature of the superheated steam, which means that the top foot of the diagonal stay must certainly be at the temperature of blue heat. It is a well known fact, established by tests and experience, that in the blue heat region iron and steel are brittle; and if bent within the blue heat zone are far more liable to crack than if at a higher temperature or at a lower temperature. As the pressure in the boiler changes, the diagonal stay will be constantly subjected to bending action and there will be danger of the diagonal stay breaking at its bend.

Arthur M. Greene, Jr. If we look sideways at the illustration of this boiler, we have practically a locomotive type boiler, especially if we put the firebox a little eccentric, and I would like to ask the author if he could include in his paper, in the discussion or the closure, some facts as regards the action of the Vanderbilt firebox in locomotive boilers, because the experience of the railroad people with that type of boiler, especially in the firebox end, would be of great value to members of this Society if they should consider the adoption of Mr. Dean's form of boiler.

Forrest E. Cardullo. I agree with Professor Greene with regard to the safety of the general form of design, and also with Professor Hibbard as regards the diagonal stay, but that matter might be very easily taken care of by carrying the boiler, in a conical form, from the joint flush with the crown sheet of the firebox up to the upper tube sheet, so as to eliminate entirely the necessity of staying that part of the boiler.

I see no reason why anyone should build a 200 h.p. vertical tubular boiler. Such a boiler, in my experience, invariably causes stack temperatures of 800 or 1000 deg., which means that it is inherently a wasteful form of apparatus, unless provision is made for utilizing the waste heat.

# THE EFFECT OF RELATIVE HUMIDITY ON AN OAK TANNED LEATHER BELT

BY WILLIAM W. BIRD, WORCESTER, MASS.
Member of the Society
AND FRANCIS W. ROYS, WORCESTER, MASS.
Non-Member[1]

It has long been a recognized fact that the weather has a more or less noticeable effect on leather belts. In experimental work it has often been found impossible to duplicate results when testing the same belt on different days. In practice, those who are familiar with the behavior of leather belts have noticed a difference in the action of belts from day to day, under varying conditions of the weather. However, when the generally accepted rules for belting are consulted, it will be found that the discussion of the weather has been entirely omitted for once. Of the several weather conditions which can be noted readily, it was thought that the variation of the relative humidity of the atmosphere would offer the most promising field and therefore the effect of this variation was chosen as the subject for a special investigation.

The most noticeable effect of an increase in the humidity was found to be in the lengthening of the belt. If the distance between the pulley centers remained constant, this lengthening of the belt would decrease the sum of the tensions. On the other hand, the sum of the tensions could be maintained by varying the center distance as the humidity was changed. Thus the field being narrowed to these limited conditions of constant initial length, width, thickness and speed of the belt; diameters of the pulleys; horse power transmitted, and temperature, the investigation was carried out to determine:

*a.* The effect produced on the center distance by varying the sum of the tensions, the relative humidity remaining constant.

*b* The effect of the relative humidity on the center distance, the sum of the tensions remaining constant.

*c* The effect of the relative humidity on the sum of the tensions, the center distance remaining constant.

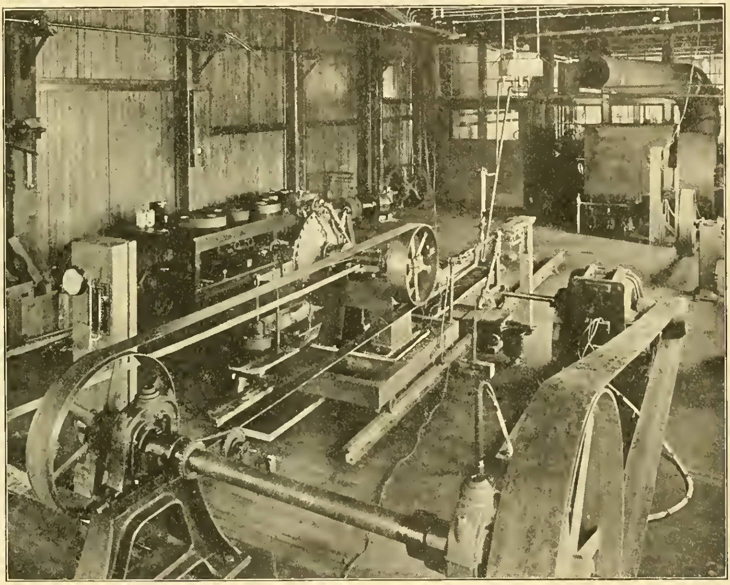

Fig. 1 General Layout of the Apparatus

A general layout of the apparatus used in these experiments, which were conducted at the Worcester Polytechnic Institute, is shown in Fig. 1. It may be described as follows:

A shaft which carries a pulley on one end and an Alden dynamometer on the other is mounted on a carriage which is free to move in a horizontal direction at right angles to the shaft. On the same level with this first shaft and parallel to it, is a jack shaft driven at constant speed. This jack shaft has a pulley on one end the same size as the pulley on the dynamometer shaft and the "belt under test" runs over these two pulleys. The Alden dynamometer furnishes the load, which is equivalent to $T_1 - T_2$ or the difference between the tensions of the tight and slack sides, and the platform scales weighs the sum of the belt tensions or $T_1 + T_2$, as shown in the figure.

In order to measure all of the power transmitted by the belt, the shaft bearings were so designed that they formed a part of the dynamometer. Fig. 2 shows this arrangement in more detail. The bearings consist of pairs of S. K. F. ball bearings in which the shaft turns. The ball bearings are carried in a housing which is free to turn inside of a

[1] Worcester Poly. Inst.

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pair of Standard roller bearings. Thus what little friction there may be in the ball bearings will tend to turn the housing which is attached to the dynamometer casing and thereby becomes a part of it.

In the rear of the room, Fig. 1, is a Sturtevant heater and blower, the heater to keep the temperature under control and the blower to circulate the air in the room. A live steam jet inside the heater was used for humidity control. The degree of relative humidity was measured by a precision hygrometer of the hair type, a wet and dry bulb thermometer and a sling psychrometre, a modification of the pattern developed by the U. S. Weather Bureau, the last method giving very satisfactory results.

The belt used in this investigation was a four-inch, single, oak tanned leather belt furnished by the Graton & Knight Mfg. Co. of Worcester. The pulleys were a pair of cast iron crown face pulleys, twenty-four inches in diameter with a six inch face. The initial length of the belt was such that the center distance at 20 per cent humidity, $T_1 + T_2$ equalling 320 lb., was 9 ft. $6\frac{9}{16}$ in.; this makes the belt approximately $25\frac{1}{2}$ ft. long. Standard conditions were assumed to be $T_1 = 240$, or 60 lb. per in. of width, and $T_1/T_2 = 3$, where $T_1$ = the tension in the tight side of the belt and $T_2$ the tension in the slack side; this gives $T_1 - T_2 =$ 160 lb. and as the belt speed remained constant at about 1900 ft. per minute, the horse power was approximately 9.21 all of the time. The slip was between 0.8 and 0.9 of one per cent.

Experiments were run to see if a difference in the modulus of elasticity of the belt, when running, could be detected at 20 per cent, 55 per cent and 90 per cent humidity. Tests were also made at these humidities to see if a difference in the slip due to different values of the modulus of elasticity could be shown. No noticeable effect could be detected. The results are plotted as curves in Figs. 3 and 4, and as a surface in Fig. 5.

The three black spots indicated on the surface of Fig. 5 all occur at $T_1 + T_2 = 320$ lb. Now starting at any one of these points and keeping the center distance constant, take the course indicated by the line along which the printing occurs. This line is seen to cross the lines of constant tension, the tension increasing as the relative humidity decreases, or vice versa.

The surface shown in Fig. 5 might well be called the characteristic of this belt, and it indicates in a general way what might be expected from similar belts. Leather itself will vary; the tanning is different; the quantity and quality of belt dressing is never twice the same. All of the factors being more or less unknown, it will be impossible to make definite prediction regarding other belts.

However, in a general way, it may be stated that the effect of a change in relative humidity is greater at high humidities than at low, that the effect is shown more rapidly in a single than in a double belt, and that increasing the humidity shows immediate results while a decrease in humidity takes some little time to be effective.

Curves are given in the paper, derived from Fig. 5 and illustrating, for belts set up at various humidities, the effect of changes in the humidity on the ratio of the tensions. Two of these relations are shown in Fig. 6, for a standard set-up of 55 per cent relative humidity, which is near the normal, and a change in relative humidity will not produce either an excessive ratio of tensions or an undue sum of tensions.

As the higher relative humidities generally occur at temperatures above 70 deg., a series of experiments was run at 50 deg. temperature with the relative humidity varying from 20 per cent to 90 per cent, and another series at 90 deg. temperature, $T_1 + T_2$ and h.p. being constant for all of these tests. These results are shown in Fig. 7, which also has the corresponding results at 70 deg. from previous experiments. This would indicate that the belt lengthens as the temperature increases, the relative humidity remaining constant; that the amount of this lengthening is somewhat greater at high relative humidities than at low relative humidities; and that the lengthening due to an increase in the relative humidity is greater at temperatures higher than 70 deg. and less for temperatures under 70 deg.

It would appear from the experiments that the lengthening

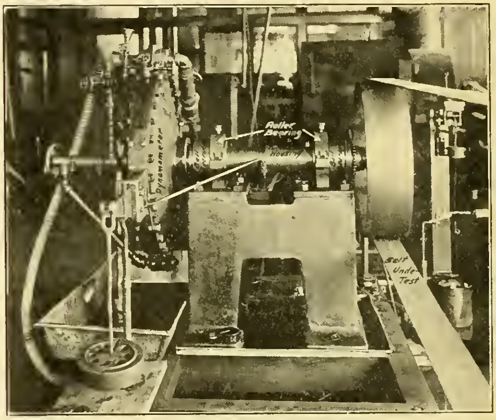



FIG. 2 DETAIL VIEW OF THE DYNAMOMETER

of the belt which takes place when the humidity increases is very nearly proportional to the relative humidity, while no definite relation to absolute humidity exists. The fact that the lines in Fig. 7 are not parallel would indicate that either there is some slight effect due to changes in the absolute humidity or, what is more probable, that the coefficient of expansion is greater at 90 deg. than at 20 deg. temperature.

The general conclusions are:

*First.* If a belt be set up at low relative humidity, slipping will probably occur if the relative humidity increases to any great extent, especially if accompanied by a rise in temperature.

*Second.* If a belt be set up at high relative humidity, excessive pressure on the bearings and stretching of the belt will result from a decided decrease in relative humidity, especially if accompanied by a fall in temperature.

*Third.* If a belt be set up at a medium relative humidity, the tensions will not be excessive at lower relative humidities, nor will there be any great danger of slipping at high relative humidities unless accompanied by excessive temperature changes, in other words, the factor of safety in the ordinary belt rules is sufficient to take care of the effect of

changes in the relative humidity if the set up be made at a medium per cent of relative humidity.

*Fourth.* If a belt be set up at any relative humidity with a spring or gravity tightener, a load 50 per cent greater than the standard can be transmitted at either high or low humidity without danger of stretching the belt, slipping or excessive pressure on the bearings.

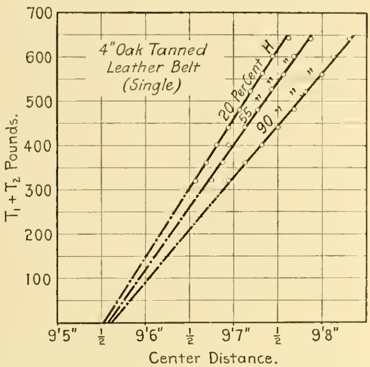



FIG. 3 RELATION BETWEEN $T_1 + T_2$ AND CENTER DISTANCE AT THREE CONDITIONS OF RELATIVE HUMIDITY. HORSE POWER CONSTANT

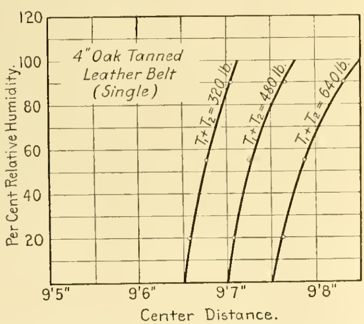



FIG. 4 RELATION BETWEEN PER CENT RELATIVE HUMIDITY AND CENTER DISTANCE AT THREE CONDITIONS OF $T_1 + T_2$. HORSE POWER CONSTANT

## DISCUSSION

GEO. N. VAN DERHOEF (written). This paper is very interesting as it goes far in explaining some of the peculiar actions of belt drives, and it is to be hoped that it will attract general attention to the subject of belt tensions. It is strange that, in all the experimental work that has been done from time to time on the transmission of power by leather belts, this feature of effect of humidity should not have been investigated before.

The results again show the importance of using spring belt clamps in tightening belts, and also that when these are used attention should be given to temperature and relative humidity. It is quite likely that those who have not found the use of spring belt clamps all they expected may find the real explanation of the matter in the disregard of these two points. It is very common to take up belts at night or on Sunday. During the winter time the temperature and relative humidity are very apt to be markedly different from those during regular working hours.

The results also show the advantage of more frequent use of belt tighteners. The highest efficiency of drive and the maximum life of the belt can only be secured by keeping the slack side tension as low as possible. The injury to the belt by bending it in the reverse direction as it goes around the tightener pulley is practically negligible if the pulley is made of large diameter; in fact, this loss and that due to the friction of the tightener is far less than that due to the extra load on the bearings of the main shafts due to the belt without a tightener never being at its condition of minimum stress

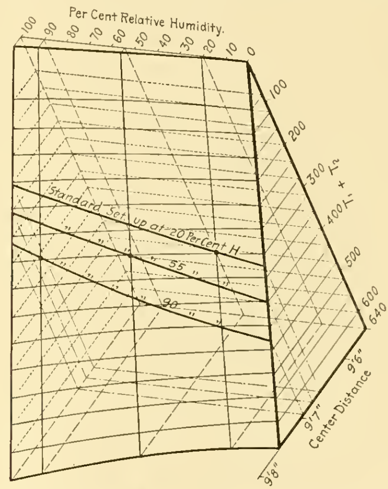



FIG. 5 BELT PERFORMANCE SURFACE FOR AN OAK TANNED LEATHER BELT 4 IN. WIDE, SHOWING RELATION BETWEEN CENTER DISTANCE, SUM OF TENSIONS AND PER CENT RELATIVE HUMIDITY

except just before taking up. A belt tightener is, however, of little value unless it is used to keep the belt just as loose as possible; it is very unfortunate that this important device was given the name of "tightener" instead of "loosener."

Nearly all belted electric generators and motors are arranged with sliding bases, and the belts used with them are considerably smaller than would generally be used with equal loads for other machinery.

The great success of the continuous system of rope transmission is due very largely to the fact that the tension can be kept at a minimum by means of the automatic tension carriage. While it is impossible to secure as favorable results with a belt drive, they can frequently be more or less approximated by the intelligent use of belt tighteners.

CARL G. BARTH wrote that some fifteen years ago, while working for the Bethlehem Steel Company, he attempted to study the influence of humidity on the tensions of two belts in the shop, by daily plotting simultaneous humidity readings and readings of belt tension scales applied to the belts. However, due to the unlooked-for extraordinary variations in the

loads transmitted by these belts (at times they would carry heavy loads and again they would run idle for days at a time), no definite results were obtained, whereas he could not help believe that results of some value would have been secured if the belts had transmitted a fairly uniform load day and night.

Previously, the drop in tensions of two other belts had been studied during the winter months, when the shop was

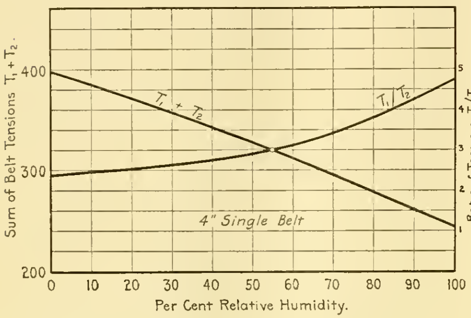



FIG. 6 EFFECT OF CHANGE OF HUMIDITY FROM 55 PER CENT. HORSE POWER CONSTANT

heated and both the temperature and the humidity thus kept within fairly small limits of variation. The results[1] were very satisfactory when the crudeness of the scales used was considered. The belts were re-tightened to a maximum tension when this had fallen to a minimum, which was carefully watched for by a system of inspection controlled by a tickler. A weakness in this has also been that on damp days old belts sometimes, and new belts frequently, reach the minimum tension between inspections, and thus at times require re-tightening during working hours, which is the very thing it was striven to avoid.

While the prescribed tension is so moderate that its rise due to a sudden drop in the humidity obtaining at a re-tightening will not do any great harm when the shaft and its bearings are properly proportioned and constructed, still it always appeared to him that some allowance should be made for the humidity, and he was of the opinion that the results obtained by the present experimenters would prove of value. However, he believed the results could be more readily applied if the experiments were repeated along the following slightly different lines:

Take a brand new first class belt and put it under an initial tension of 240 lbs. per square inch of cross section, over revolving pulleys transmitting no power. Measure its length under this tension while the humidity is kept constant. Keep this up until the tension has fallen to 120 lbs., or one-half the original amount. Re-tighten the belt over the same pulleys to 240 lbs. by cutting out the necessary fraction of its length, note this length, and proceed as before; repeat this procedure for at least one school year.

During the next two school years, repeat the process under different degrees of humidity, and with belts of the same size and make and preferably cut from the same roll as the first, or, if this is not feasible on account of expense, build and equip three separate rooms for the purpose and do all the work in one year.

Next, thoroughly impregnate the belts with some good belt dressing, such as Kling-Surface or Plomo, and repeat the experiments. It is claimed, and it is undoubtedly true, that belt dressings keep out the moisture to a considerable extent.

He was sure that the results to be obtained by a constant length of the belt under no load transmission would be more readily applicable in practice than would the results obtained by a constant load transmission with variable belt length.

F. G. GILBRETH thought we paid too much attention to the cost of the belt; it is to the cost of the up-keep of the belt and its effect on the achievement of the task of the worker that we should look, and he would like to know the effects of these experiments if carried on in practice on those two features.

WM. S. ALDRICH (written). Considering the number of variables and the atmospheric conditions to be controlled,

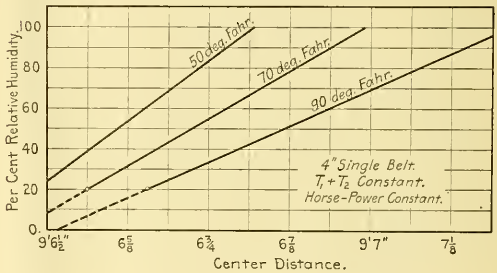



FIG. 7 RELATION BETWEEN CENTER DISTANCE AND RELATIVE HUMIDITY OF THREE DIFFERENT TEMPERATURES

the results are well worthy of attention in the every-day use of belting. Especially will this attention be possible in factories having heating and humidifying systems under more or less automatic control. The factors of temperature and humidity have already been found to influence shop production, and the cost of regulating them is more than compensated in certain lines and developments through increased economy and efficiency, and the enhanced general welfare of the workmen.

Setting up the belt, therefore, under the standard and maintained temperature and humidity of the shop, may come to be the order of the day. The 55 per cent relative humidity chosen by the authors for their standard test comparisons seems reasonable, but the 70 deg. temperature chosen as an accompanying standard shop temperature would be uncomfortable in practice. The best working temperature is still a mooted question and depends on the class of workmen, the kind of physical work and the humidity. The best range is probably a little under or over 60 deg., according to local circumstances. 60 or 62 deg. is also about the standard normal temperature for comparisons of engineering data, in English measures.

The barometric pressure must be taken into consideration in standardizing atmospheric conditions with regard to the

[1] Transmission of Power by Leather Belting, Barth, Trans. A. S. M. E., vol. 31, p. 43.

relative and absolute amount of moisture present. It is not unusual for this to range over two inches of mercury in the course of a day in very changeable weather. Were barometric readings taken throughout and all observations reduced to standards of comparison for the conditioned relative humidity selected?

A careful study of the comparative results at different temperatures, illustrated in Fig. 7, will show that it is probably the actual amount of moisture present in the air which most influences the stretch of the belt, and this is, therefore, the determining factor. In the diagrams, the scale values of the relative humidity may be interpreted as directly proportional to the actual moisture, assuming, however, that the barometric pressure was constant throughout the test.

From Meteorological Tables[1], the absolute amount of moisture present in the air under standard conditions, is:

| | | | |
|---|---|---|---|
| Deg. fahr. | 50 | 70 | 90 |
| Gr. Troy | 4.076 | 7.980 | 14.780 |

In other words, at the standard conditioning of the air in the shop of 55 per cent relative humidity, the actual moisture in the air, at the above temperatures will be 2.24, 4.39 and 8.13 grains, respectively. These weights are not quite in geometric progression, but they are sufficiently cumulative to suggest interesting comparisons. They show to what extent the belt can absorb moisture as the temperature rises—how hygroscopic it really is. In short, the belt seems to have almost unlimited capacity to absorb moisture as the temperature of the air rises, and in comparison with the accompanying equal increments of belt stretch under test.

The authors have well pointed out that the difficulties inherent with so many variables as naturally arise in belt testing indicated constant speed and constant load as prerequisites. It would be interesting to know how these latter might vary under varying humidity with constant center distance. It is this latter condition which is imposed on the belt in actual service. For precise work in certain driving operations, it may even be desirable to go to the expense of waterproofing the belt if this should prove feasible.

A. F. Nagle (written). This is a laboratory experiment and as such has an educational value, but its practical value may be questioned. Practical considerations, that is, men and materials, do not admit of too great refinements. Belt tensions should be adjusted by a mechanical engineer, with spring scales to guide him; but the operating mechanic will cut out an inch, more or less, if he finds a belt does not drive his machine. When the works are large enough to employ special men to attend all belts, something like the refinements alluded to in this paper may be carried out, but even then the practice is liable to fall into disuse.

The author should give the actual thickness of the belt used. Single thickness is not specific enough, for belts in the market vary nearly two to one in thickness.

W. W. Bird replied that if a belt is fitted up with a spring or gravity tightener, it practically adjusts itself, and a very material difference is made in regard to the up-keep. He was running a great many machines with an idler or spring arrangement to take up and tighten the belt, and this is done automatically; the arrangement not only lengthens the life of the belt, but also has a bearing on the question of upkeep. The question of a few dollars for a belt is nothing in comparison with the loss of use of a machine.

[1] Smithsonian Institution, Washington, D. C.

# LAPS AND LAPPING

BY W. A. KNIGHT, COLUMBUS, O.

Member of the Society

AND A. A. CASE, COLUMBUS, O.

Non-Member[1]

The process of working down a surface by lapping, that is by wearing it down by the use of a loose-grained abrasive in connection with a lubricant was first applied in the grinding and polishing of precious stones. Later the process was applied to the working of hardened steel, and, from this, gradually extended to cover a wide variety of operations common to machine-shop practice.

There are two methods of using a surface lap which, for want of better definitions, will be termed the "wet" and the "dry" methods. In the wet method there is a surplus of oil and abrasive on the surface of the lap.

With the dry method, the lap is first charged by rubbing or rolling the abrasive into its surface. All surplus oil and abrasive is then washed off, leaving a clean surface, but one that has embedded uniformly over it small particles of the abrasive. It is then like the surface of a very fine file or oil stone and will cut away hardened steel that is rubbed over it.

The lubricants most commonly used for lapping are lard and machine oils, kerosene, and gasoline. Alcohol and turpentine have been recommended. It is well known that turpentine can be used to advantage when drilling hard steel.

Abrasive materials are usually emery, alundum, corundum, carborundum, or others of a similar kind, but sold under various trade names, as Crystolon, Axolite, Carbondite, etc. Diamond dust, ground glass, oil stone powder, and ground pumice stone are used for certain kinds of work.

The object of the experiments described was to secure, if possible, reliable data on:

*a* The relative efficiencies of the different abrasives.

*b* The relative efficiencies of different lubricants.

*c* The rate of cutting with laps made of cast iron, soft steel, and copper.

*d* The wear of the laps, compared one with the other and with the amount of steel ground off with each.

*e* The effect of pressure on the rate of cutting.

*f* The rate of cutting by the wet and the dry methods.

To carry out the experiments, a machine was constructed with which quantitative results could be obtained with various combinations of abrasive, lubricant and lap material.

The usual method was followed of keeping all variables constant except one, and, having determined the effect of that one, to proceed to the next. It developed, however, that some of the variables affecting the results were not entirely within control. Thus, for instance, the size of the grains of abrasives is one of the factors affecting the rate of cutting, and this factor is continually changing during the process.

Again, when using volatile liquids, like gasoline, turpentine, and alcohol, fresh additions had to be made to the plate to make up the loss from evaporation.

[1] Instructor, Ohio State Univ.

Presented at the Spring Meeting of the Society, June 1915. Complete paper may be obtained without discussion; price 15 cents to members; 30 cents to non-members.

Thorough precaution was taken to reduce all uncertain factors to the lowest possible limit and confidence is felt that the results are well within the limits of practical accuracy.

The machine which was designed and used for these tests is shown in Fig. 1. The horizontal shaft *B*, driven by motor *A*, transmits motion through spiral gears to two vertical shafts *C* and *D*. Shaft *C* carries the lapping plate at its upper end and shaft *D* the slotted crank disk *E*, by means of which, and the connecting rod *F*, the specimen holder *H* is made to reciprocate between the center and outer edge of the lapping plate. The motions of the lapping plate and specimen holder cause the latter and its specimen to follow a path relative to the plate like that shown in Fig. 2.

As at first constructed the machine was autographic, but too many uncertainties were introduced by the friction of the pencil and other conditions and this feature was finally abandoned.

The specimen holder is shown in section in Fig. 3. The specimen is held in the hardened steel bushing *o* in end of lever *l*, which receives its motion through connecting rod *f* to which it is attached by studs *m* and *n*. The specimen is held against the lapping plate by the pressure of the weights, shown in the figure, transmitted to the specimen through the yoke *e*, screw *s* and pin *j*. These parts are supported by a tube *a* held by the split block *b* which in turn is clamped to the connecting rod *f*.

The nut *d*, through which passes the screw *s*, is of tool steel, hardened, ground and lapped to a smooth working fit in the tube. At *k* is a hardened steel plug, which is also a smooth working fit in the tube. This plug has a conical seat at each end in which bear the tapered ends of screw *s* and pin *j*. A perfectly free vertical motion is obtained, whereby the weights can follow up the wear of the specimen with practically no friction.

The bushing *o* which carries the specimen is counterbored in order that any side thrust may be brought as near the lower surface of the specimen as possible. To move the specimen from under the tube for examination, or removal, the knurled nut *n* is loosened, thus permitting the arm *l* to to be turned about the stud *m*.

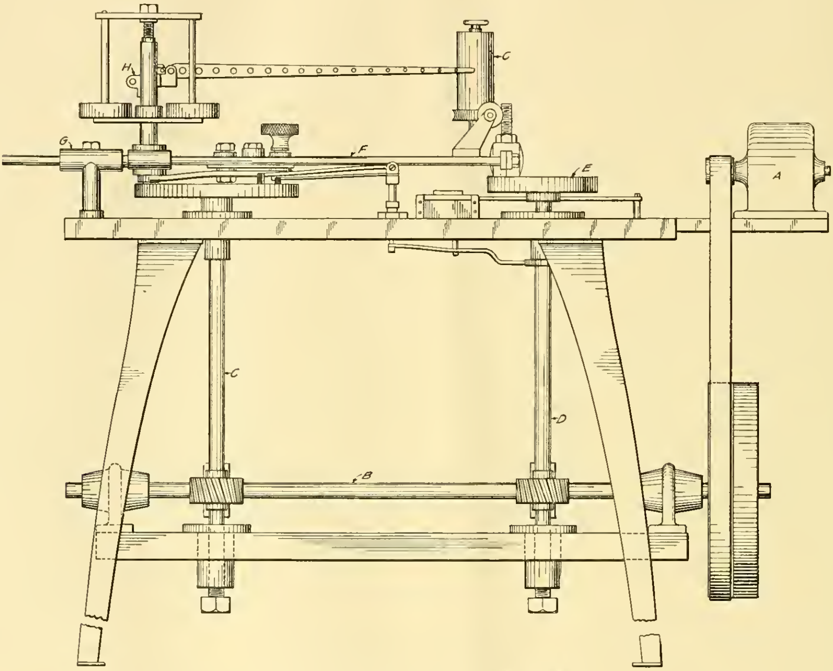



FIG. 1 SIDE ELEVATION OF MACHINE

The lapping plate is shown in section in Fig. 4. The lap surface is at *A*. A gray iron plate, cast originally ½ in. thick and finished down to ⅜ in. thick, is held to the lower plate *B* by means of screws. The outer rim *C* is also fastened by screws and is removable.

The copper and steel laps were built up the same way. The copper plate was made of plate copper ¼ in. thick; since this was too thin to be tapped into, it was secured to the cast plate by means of solder. The steel plate was made of fire-box steel ¼ in. thick and secured in the same manner as the copper plate. The surfaces of all laps were finished by grinding.

The distributor, or wiper, is an important feature of the machine. It is shown in detail in Fig. 5. It was essential that there be a uniform distribution of the charge of abrasive over the entire surface of the plate. Centrifugal force was depended upon to work the charge from the center of

the plate outward, and a wiper, $T$, consisting of a strip of wood resting on the plate and inclined at an angle of 15 deg. to a radial line from the center, was counted on to shear the charge back toward the center. Motion was given to the wiper through the medium of an eccentric $R$ placed on the shaft $D$. To prevent an accumulation of part of the charge around the inner surface of the outer ring, a small auxiliary wiper was placed as shown at $Q$.

The test specimens were of hardened tool steel, of ⅝-in. drill rod. Fifty-five pieces ½ in. long were cut from the same bar and numbered consecutively. They were hardened by heating in the muffle of a regulated gas furnace, and quenching in clear salt water.

Three abrasives were selected as being representative of those on the market. These were Naxos Emery, from the Safety Emery Wheel Co., Springfield, O.; Carborundum, di-

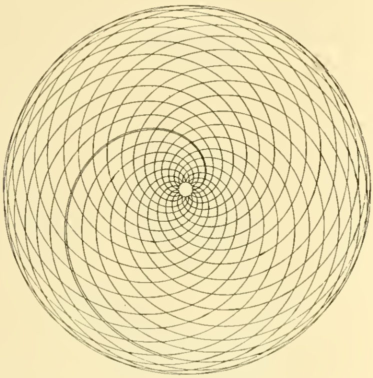


FIG. 2 OUTLINE TRACED BY SPECIMEN ON LAP

rect from the Carborundum Company, Niagara Falls, N. Y., and Alundum, from the Norton Company, Worcester, Mass. All the tests were carried out with abrasive No. 150. Each of the abrasives was tried with seven different lubricants, five different pressures, and three different laps. The lubricants were lard oil, machine oil, kerosene, gasoline, turpentine, alcohol, and soda water.

Starting a series of tests, say with emery as the abrasive and with cast iron lap, the first test was made with lard oil and with a pressure of 5 lb. per sq. in. on the specimen. The pressure was then increased to 10 lb. per sq. in., other conditions remaining the same, and another run made. The pressures were then increased to 15, 20, and 25 lb., giving a group of five runs with lard oil.

Machine oil was then substituted for lard oil and a like group of tests made, after which tests were made with the other lubricants in the same way. This gave for cast iron-emery a series of 35 tests.

Carborundum was next substituted for emery and the same number of tests repeated. This was followed by a like series with alundum, making the total number of tests with cast iron lap 105.

The cast iron lap was then replaced by one of steel and a second series of 105 tests run with the steel lap. This was followed by a like series with the copper lap.

The conditions of the tests are described fully in the paper.

The log of a single test is shown in Fig. 6, while Fig. 7 shows the plotted results of a typical individual test of the cast iron-emery series. A summary of all the results of tests is given in Table 1.

TABLE 1 SUM OF AMOUNTS GROUND FROM SPECIMENS WITH PRESSURES OF 5, 10, 15, 20, AND 25 LB. PER SQ. IN.

| | | Machine Oil | Lard Oil | Kerosene | Gasoline | Turpentine | Alcohol | Soda Water | Total |
|---|---|---|---|---|---|---|---|---|---|
| Cast Lap | Emery | 1320 | 1673 | 3324 | 3955 | 2336 | 2392 | 3105 | 18105 |
| | Alundum | 1849 | 2313 | 3687 | 4291 | 3230 | 3251 | 3112 | 21733 |
| | Carborundum | 2825 | 3340 | 4230 | 4520 | 4458 | 4427 | 3873 | 27673 |
| | Total | 5994 | 7326 | 11241 | 12766 | 10024 | 10070 | 10090 | 67511 |
| Steel Lap | Emery | 1744 | 2460 | 2720 | 3034 | 2560 | 2608 | 2839 | 17965 |
| | Alundum | 1800 | 2537 | 3622 | 3627 | 3400 | 3388 | 3338 | 21712 |
| | Carborundum | 4199 | 4649 | 3805 | 3980 | 3983 | 3527 | 4045 | 28188 |
| | Total | 7743 | 9646 | 10147 | 10641 | 9943 | 9523 | 10222 | 67865 |
| Copper Lap | Emery | 3250 | 3454 | 3756 | 3813 | 3598 | 3961 | 3780 | 25612 |
| | Alundum | 3971 | 4065 | 3763 | 3960 | 4171 | 4097 | 4472 | 28499 |
| | Carborundum | 4148 | 4540 | 3692 | 3724 | 4251 | 4081 | 4210 | 28646 |
| | Total | 11369 | 12059 | 11211 | 11497 | 12020 | 12139 | 12462 | 82757 |
| | Grand total for each lubricant | 25106 | 29031 | 32599 | 34904 | 31987 | 31732 | 32774 | |

In Fig. 8 is given a typical series of characteristic curves obtained by summing up the ordinates of the individual test curves for the different lubricants, abrasives and lap materials. For instance, the gasoline curve in this figure is obtained by summing up all the ordinates of the five curves in Fig. 7.

*Lubricants.* The action of the different lubricants presents an interesting study. The same lubricant acts differently with the different abrasives and again differently with different laps.

Taking the results of the emery-cast iron series of tests alone, as shown in Fig. 8, it would seem that the change in the viscosity and lubricating properties would offer a reasonable and fairly complete explanation of the difference in their behavior. Gasoline, which is lowest in these respects, has the highest rate of cutting, which is well maintained, being nearly as high at the end of 4000 rev. as at the beginning. Next is kerosene, the rate of cutting of which is high, but which shows slightly more of a decreasing rate as the end of the run is approached. Soda water is below kerosene, but maintains its rate of cutting more like gasoline.

The paper here includes a detailed consideration of the results from various lubricants. The following is a summary:

*Lard and Machine Oil.* For these lubricants, it is to be observed:

*a* That in tests under all conditions, their curves are of the same form and follow each other closely.

*b* That lard oil without exception gives the higher rate of cutting.

*c* That in general the initial rate of cutting is higher than with the lighter lubricants, but falls off more rapidly as the run proceeds.

*d* That both the highest and lowest results of the whole number of tests were obtained with these two lubricants. The lowest with machine oil, emery-cast iron lap, with lard oil a little above it; the highest with lard oil, carborundum-steel lap, with machine oil a little below it.

Table 2 shows this progressive increase in the values obtained with the different combinations:

TABLE 2 AMOUNT GROUND FROM SPECIMEN WITH MACHINE AND LARD OIL FOR THE DIFFERENT COMBINATIONS OF LAP AND ABRASIVE

| | Machine Oil | | | Lard Oil | |
|---|---|---|---|---|---|
| Cast Lap | Emery | 1320 | Cast Lap | Emery | 1673 |
| | Alundum | 1849 | | Alundum | 2313 |
| | Carborundum | 2825 | | Carborundum | 3340 |
| Steel Lap | Emery | 1744 | Steel Lap | Emery | 2460 |
| | Alundum | 1800 | | Alundum | 2557 |
| | Carborundum | 4199 | | Carborundum | 4649 |
| Copper Lap | Emery | 3250 | Copper Lap | Emery | 3459 |
| | Alundum | 3997 | | Alundum | 4065 |
| | Carborundum | 4148 | | Carborundum | 4540 |

*Gasoline and Kerosene.* On the cast iron lap gasoline shows the highest results of any of the lubricants tested. It is not so good on copper and still less so on steel. Taking into account all three abrasives, its relative value on the different laps is as follows:

Cast iron 127 Copper 115 Steel 106

Kerosene shows more nearly the characteristics of gasoline than of the heavier oils. Like gasoline, it gives the best results on cast iron and the poorest on steel. It does not work so well with carborundum on the copper lap.

*Turpentine and Alcohol.* There is no evidence to show that turpentine possesses any superior advantage over the other lubricants. On any lap it does good work with carborundum. With emery it does fair work on the copper lap, but with emery on the cast iron and steel lap it is distinctly inferior.

Alcohol in some ways acts very much like turpentine. It also gives the lowest results with emery on the cast iron and steel laps.

*Soda Water.* Soda water gives reasonably good results with almost any combination of lap and abrasive. While it is seldom the best, it is never the worst. It does its best work on the copper lap and poorest on steel, although there is not much difference between its work on the cast iron and steel. On the cast iron lap it does better work than machine or lard oil, but not so good as gasoline.

*Abrasives.* It may be well to call attention to the fact that emery and alundum are similar abrasives, both being aluminum oxides of the form $Al_2O_3$. Emery is a natural product, more or less contaminated with iron or other impurities. Alundum is an artificial product and, in general, of greater purity than the natural product. Carborundum, on the other hand, is an entirely different material, being a carbide of silicon, SiC. Naturally, then, emery and alundum might be expected to show more nearly the same characteristics, while carborundum would deviate more or less from them.

The curves in Figs. 9 and 10 show the rates of cutting for the three abrasives with cast iron lap, and with machine oil and lard oil respectively. The paper gives similar sets of curves for all the different combinations of lap and lubricant.

The total amounts of steel ground from the specimens with each abrasive are given in Table 3.

TABLE 3 AMOUNTS IN MILLIGRAMS GROUND FROM SPECIMENS WITH DIFFERENT COMBINATION OF LAP AND ABRASIVE

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Cast Lap | Emery | 18105 | Steel Lap | Emery | 17965 | Copper Lap | Emery | 25612 |
| | Alun. | 21733 | | Alun. | 21712 | | Alun. | 28499 |
| | Carb. | 27673 | | Carb. | 28188 | | Carb. | 28646 |

The evidence all the way through tends to the conclusion that there is for each different combination of lap and lubricant a definite size grain of abrasive that will give maximum rate of cutting.

The hardness of the various laps, as determined by the research department of the Westinghouse Electric and Manufacturing Co., was as follows:

By the brinell method
Cast iron 109 Steel 87 Copper 43.6

By the sclerescope
Cast iron 28 Steel 18 Copper 5

A comparison of the three laps with all combinations of abrasive and lubricant is given in twenty sets of curves. Two sets are shown in Figs. 11 and 12.

Figures are given to show that, with the proper abrasive

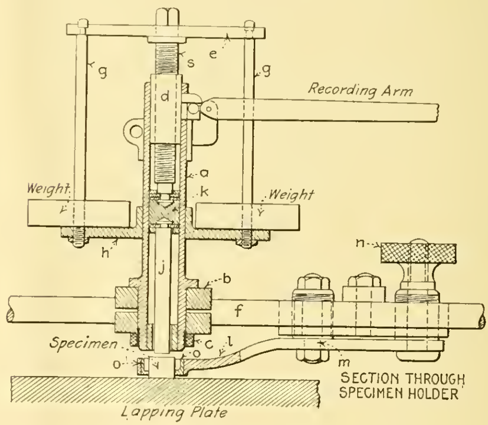



Fig. 3 Section through Specimen Holder

and lubricant, steel and cast iron are equally as good (for all practical purposes) as copper.

*Wear of Laps.* One of the remarkable facts brought out was the great difference in wear of the laps. The wear on all laps was about twice as fast with carborundum as with emery, while with alundum the wear was about one and one-fourth times that with emery. On an average the wear of the copper lap was about three times that of the cast lap. Table 4 shows this clearly.

TABLE 4 AMOUNTS GROUND FROM THE LAP SURFACE FOR EACH 100 MILLIGRAMS GROUND FROM THE SPECIMEN

| | Emery | Alundum | Carborundum | Total |
|---|---|---|---|---|
| Cast iron | 81.2 | 118 | 158 | 357.2 |
| Steel | 114 | 149 | 190 | 453 |
| Copper | 233 | 295 | 410 | 938 |

As regards permanence of form, cast iron is altogether better than either steel or copper, and taking into account its first cost and that with proper abrasive and lubricant its rate of cutting is practically as good as copper or steel, it is far and away the best lap material.

From results obtained on the wear of the laps, it is evident that the theory of the lodgment of the abrasive in the softer lap surface is not well founded. The action appears to be more mutual between the surfaces.

Within the limits of the pressures used; that is, up to 25

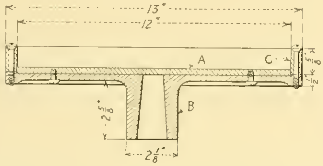



Fig. 4 Section through Lapping Plate

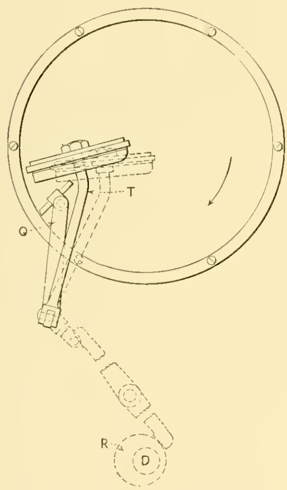



Fig. 5 Plan of Distributor

lb. per sq. in., the rate of cutting is practically proportional to the pressure.

The higher pressures, 20 and 25 lb. per sq. in., did not do so well on the copper lap as on the others. There was some evidence tending to show that for this lap the practical limits of pressure had been reached.

Of the 63 combinations tried out, the 15 giving best results are presented in Table 5.

*Dry Lapping.* Experiments on dry lapping were carried out on the cast iron, steel and copper laps and also on one of tin made expressly for the purpose.

Carborundum alone was used as the abrasive and a uniform pressure of 15 lb. per sq. in. was used on the specimen throughout the tests. In dry lapping much depends on the manner of charging the lap.

The results of these tests are shown in curves in the paper

TABLE 5 COMPARATIVE VALUES OF THE BEST COMBINATIONS, TAKING EMERY-CAST IRON LAP AND MACHINE OIL AS UNITY

| | |
|---|---|
| Carborundum—Steel lap —Lard oil | 3.52 |
| Carborundum—Copper lap—Lard oil | 3.44 |
| Carborundum—Cast lap —Gasoline | 3.42 |
| Alundum —Copper lap—Soda water | 3.39 |
| Carborundum—Cast lap —Turpentine | 3.37 |
| Carborundum—Cast lap —Alcohol | 3.35 |
| Alundum —Cast lap —Gasoline | 3.25 |
| Carborundum—Copper lap—Turpentine | 3.22 |
| Carborundum—Cast lap —Kerosene | 3.20 |
| Carborundum—Copper lap—Soda water | 3.19 |
| Carborundum—Steel lap —Machine oil | 3.17 |
| Alundum —Copper lap—Turpentine | 3.15 |
| Carborundum—Copper lap—Machine oil | 3.14 |
| Alundum —Copper lap—Alcohol | 3.10 |
| Carborundum—Copper lap—Alcohol | 3.09 |

and are tabulated in Table 6. Fig. 13 gives one set of curves.

The greatest difference due to different charging is shown by the tin lap. When abrasive No. 150 is rolled into its surface the cutting is about two and one-half times as fast as when the same abrasive is rubbed in. Also it is about three times as fast as when abrasive "F" is rolled, and six times as fast as when "F" is rubbed in.

TABLE 6 RESULTS OF TESTS ON DRY LAPPING

| | | Revolutions | | | |
|---|---|---|---|---|---|
| | | 100 | 200 | 300 | 500 |
| | Lap | Milligrams ground from specimen | | | |
| Carborundum No. 150 lap charged by rolling | Cast | 3.6 | 6 | 7.6 | 8.6 |
| | Steel | 10.3 | 13 | 15.3 | 16.6 |
| | Copper | 11.3 | 16.3 | 19 | 23.3 |
| | Tin | 18.6 | 25.6 | 30.6 | 39 |
| Carborundum No. 150 lap charged by rubbing | Cast | 2 | 3.3 | 4 | 5 |
| | Steel | 6.6 | 8.6 | 9.6 | 11 |
| | Copper | 6.6 | 9.6 | 11.6 | 13.6 |
| | Tin | 7.3 | 10.3 | 12.3 | 15.3 |
| Carborundum "F" lap charged by rolling | Cast | 8.6 | 12.6 | 14.6 | 16.6 |
| | Steel | 6.3 | 8.3 | 9.3 | 10.6 |
| | Copper | 6 | 8 | 9.6 | 11 |
| | Tin | 7 | 9.3 | 10.3 | 12 |
| Carborundum "F" lap charged by rubbing | Cast | 2.6 | 5 | 6 | 7 |
| | Steel | 5 | 7 | 8 | 9 |
| | Copper | 3 | 5 | 6.6 | 8.6 |
| | Tin | 2 | 4 | 5 | 5.3 |

It thus appears that with soft and ductile materials like copper and tin the best results are to be obtained by rolling a comparatively coarse abrasive into the surface, but that with a harder and more brittle material like cast iron a finer grade should be used.

A comparison between the wet and dry methods is more or less unsatisfactory. In dry lapping the rate of cutting decreased rapidly after the first 100 revolutions of the machine—much more rapidly than with the wet method. It seems no more than fair, then, in making comparisons to consider the amounts ground off during the first 100 revolutions. Further, the highest result obtained with each lap is taken as the basis of comparison. With these data, it is found that with the tin lap, charged by rolling carborundum No. 150 into the surface, the rate of cutting, dry, approaches that of the wet. With the other laps, the rate for dry is about ½ that of the wet. Table 7 exhibits this.

It may be of interest to know the rate of cutting in linear measure. With the size of specimen used, the removal of 39 milligrams represented a length of 0.001 in. With a pressure of 15 lb. per sq. in., the average of the best results was just about 22 mg. for 100 revolutions of the machine. The length of path traversed by the specimen was 36 in., or 3 feet per revolution. Hence, the specimen moved over the lap a distance of 300 ft. to have ground from its surface 0.00056 in., or 0.00019 in. for 100 ft. of travel over the lap surface.

With dry lapping on the tin lap, the best result was 18.6 mg. for 100 revolutions, which gives 0.00016 in. per 100 ft. of travel. This is with a pressure of 15 lb. per sq. in. on the specimen, and, of course, with a higher pressure a greater amount would be ground off.

Test No. 92 date 3-12-13 Observer - Knight

Abrasive - Emery - Grade 150 - Lubricant M. Oil Pressure 15 lbs.

| Reading of Counter | Reading of Counter | Revolutions | Weight beginning of run | Weight end of run | Weight ground off |
|---|---|---|---|---|---|
| 21000 | 21500 | 500 | 19330 | 19240 | 90 |
| | 22000 | 500 | | 19186 | 54 |
| | 23000 | 1000 | | 19139 | 47 |
| | 24000 | 1000 | | 19110 | 29 |
| | 25000 | 1000 | | 19090 | 20 |
| | | | | | |
| | | | 19330<br>19090 | | 90<br>144 |
| | | | 240 | | 191<br>220 |
| | | | | | 240 |
| | | | | | |

Fig. 6 Log of a Typical Test

The main facts, as developed by the investigations and deductions therefrom, are summarized as follows:

*a* The initial rate of cutting is not greatly different for the different abrasives.

*b* Carborundum maintains its rate better than either of the others, alundum next, and emery the least.

*c* Carborundum wears the lap about twice as fast, and alundum $1\frac{1}{4}$ times as fast as emery.

*d* There is no advantage in using an abrasive coarser than No. 150.

*e* The rate of cutting is practically proportional to the pressure.

*f* The wear of the laps is in the following proportions:
Cast iron 1.00 Steel 1.27 Copper 2.62

*g* This wear is inversely proportional to the hardness by the brinnel test.

*h* In general, copper and steel cut faster than cast iron, but where permanence of form is a consideration, cast iron is the superior metal.

TABLE 7 COMPARISON OF WET AND DRY LAPPING; PRESSURE, 15 LB.; ABRASIVE, CARBORUNDUM; 100 REV. OF MACHINE

| | Best results with | | | |
|---|---|---|---|---|
| | Cast Lap | Steel Lap | Copper Lap | Tin Lap |
| Wet | 20 | 24 | 22 | .... |
| Dry | 8 6 | 10 3 | 11 3 | 18.6 |

*i* Gasoline and kerosene are the best lubricants to use with cast iron lap; kerosene, on account of its non-evaporative qualities, being first choice.

*j* Machine and hard oil are the best lubricants to use with copper or steel lap. They are least effective on the cast lap.

*k* For all laps and all abrasives (of those tested), the cutting is faster with lard oil than with machine oil.

*l* Alcohol shows no particular merit for the work.

*m* Turpentine does fairly good work with carborundum, but in general is not as good as kerosene or gasoline.

*n* Soda water compares favorably with other lubricants. Taken as a whole, it is slightly better than alcohol and turpentine.

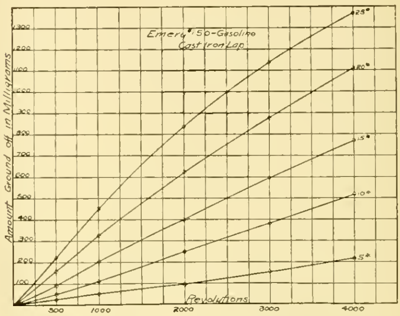



Fig. 7 Characteristic Cast Iron-Emery Test

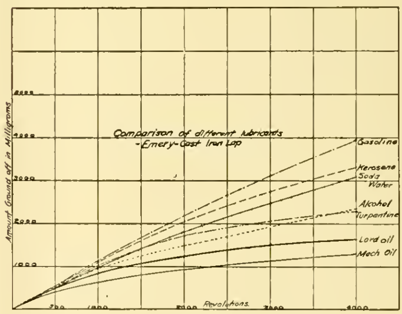



Fig. 8 Comparison of Lubricants

*o* Wet lapping is from 1.2 to 6 times as fast as dry lapping, depending on material of the lap and manner of charging.

In an appendix is given a rather full bibliography of the subject of lap and lapping.

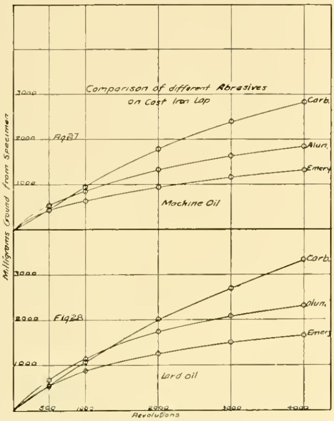
## DISCUSSION

Charles E. Gillette (written). Except for the work of Schlesinger at Charlottenburg, in 1906, for the Prussian Department of Commerce and Labor, very little of a purely scientific character covering grinding has been published. Professor Alden in his paper, Operation of Grinding Wheels in Machine Grinding, presented before this Society last De-

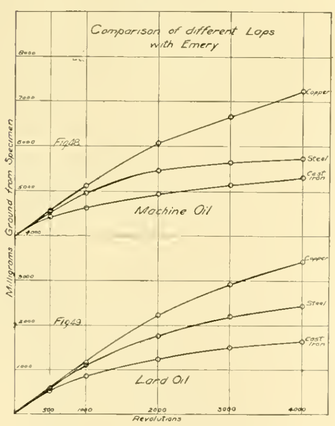
cember, sets forth the controlling factors governing the action of abrasives when used in the form of grinding wheels; the principles brought out in his paper will form the basis of much valuable experimental work in the future.

The authors are, therefore, to be complimented for their addition to the small store of available data on the action of abrasives under actual operating conditions.

In lapping, as in other operations requiring the use of abrasives for the removal of material, rule of thumb methods have predominated, and such information as has been obtained cannot be said to have been based upon scientific investigations.




Figs. 9-10 Comparison of Abrasives




Figs. 11-12 Comparison of Laps

Lapping, in the sense accepted by our best mechanics, infers the use of a perfect master surface to obtain upon a piece of work a level surface and a certain finish or accuracy of dimensions compatible with the purpose for which the lapped piece is to be used. In tool making, where accurate duplication of parts is necessary, lapping reduces the chance for wear and insures the maintenance of standards. In optical work lapping is resorted to for the purpose of obtaining as near as possible absolutely accurate dimensions, together with a finish or polish that will not interfere with the passage of light waves.

For roughing or blocking down, that is, where the work has not been ground on a surface grinding machine previous to the lapping operation, a different method is used. It would seem, therefore, that while the authors have conducted tests along the methods used in blocking down, the information obtained regarding the action of the abrasives could not be successfully utilized in actual lapping practice.

The point which is most forcibly brought out is that car-

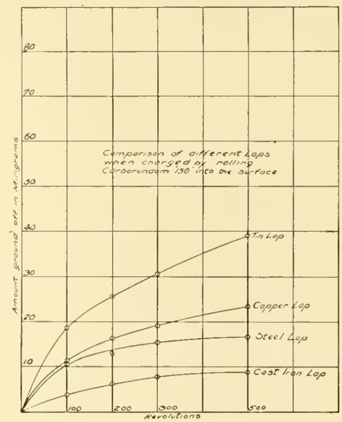



Fig. 13 Typical Curves of Dry Lapping Tests

bide of silicon acts more efficiently on hardened steel than do the aluminous abrasvies. One of the absolute laws of grinding is that aluminous abrasives act more efficiently on materials of high tensile strength, like steel and its alloys, while the carbide of silicon is most efficient on materials of a low tensile strength, such as cast iron, brass, bronze, etc. This is due to the physical properties of the two abrasives, the one being very hard and tough while the other is slightly harder, but relatively quite brittle.

However, lapping may bring into action different properties of the abrasives than is obtained in the solid abrasive wheel. In lapping, the grains are under compression, while in a grinding wheel each grain on the grinding surface might be considered a cantilever subjected to sudden loading at its end, repeated with great frequency.

Considering that the action of an oilstone is like that of a lap which has been charged by either having the abrasive rubbed or rolled into it, the results of a series of tests conducted by the Norton Company may be of interest. The object of these experiments was to compare the cutting qualities of oilstones made of aluminous and carbide of silicon abrasives. The only variable was the composition of the oilstones —there being one aluminous and three carbide of silicon abrasives used. The lubricant was a light grade of machine oil.

A universal grinding machine was used in the test, a special attachment being devised to hold the test piece—a hardened steel chisel with a $1\frac{1}{2}$ in. blade. The oilstone was

clamped to the table of the machine and traversed under the chisel blade at a fixed velocity. The chisel was so prepared that the surface in contact with the oilstone measured $1\frac{1}{2}$ by $\frac{1}{2}$ in.

A pressure of 40 lb. per sq. in. was selected as giving sufficiently accurate results. It was found necessary to use an excessive amount of lubricant to prevent the oilstone from loading or filling up before the end of the test. The chisel blade was traversed a distance of 500 ft. across the oilstone, the stone then being turned over and a run of 500 ft. being made on the other side of the same stone.

While the testing apparatus was not as nicely adjusted as the machine described in the paper, the results obtained were considered sufficiently accurate for commercial purposes. A summary of them follows: Milligrams removed from chisel per 1000 ft. travel across the oilstones

| | |
|---|---|
| Alundum | 145 |
| Carbide of Silicon No. 1 | 33 |
| Carbide of Silicon No. 2 | 42 |
| Carbide of Silicon No. 3 | 90 |

These results indicate, without question, that the aluminous abrasive cuts the hardened steel tool much faster than carbide of silicon when used in the form of an oilstone. The size of abrasive used on the oilstones corresponds very closely to the sizes used by Professor Knight in his test.

A very interesting question has been brought out by these tests which ought to be given further consideration. Is there a certain "critical point," so-called, at which all abrasives have an equivalent cutting action under identical test conditions, and either side of which each type of abrasive has its own distinctive field? In other words is carbide of silicon in the coarse sizes more efficient on materials of a low tensile strength and in the fine sizes more efficient on materials of a high tensile strength than aluminous abrasives? A theoretical consideration of the physical properties of the two types of abrasives will show why the action of loose abrasive grains as used in rough lapping may be considerably different than when they are held more or less solidly in a body, such as a charged lap, oilstone or grinding wheel.

The U. S. Bureau of Standards places the hardness of carborundum at 9.6, alundum 9.4 and emery at approximately 9 on Mohr's scale. Carborundum, a carbide of silicon abrasive, is brittle. Alundum and emery, aluminous abrasives, are very tough in comparison. Tests upon grains of emery, alundum and carborundum show the relative compressive strength to be approximately as 1.00: 1.8: 2.0. This shows that emery would break down under straight compression first, alundum second and carborundum last.

Professor Knight states "emery appears to be more brittle and passes through the change quicker than the others, with alundum next and carborundum the least susceptible to such a change." Thus it would seem that in blocking down, where the abrasive grains are compressed between the lap and work, the ability to resist crushing is a more important factor than the actual hardness or toughness. Emery, being relatively weaker in compression, breaks down into the impalpable sizes faster than the other abrasives, hence does less effective work during the period of test. This presupposes that the coarser sizes of abrasives cut the faster.

With the abrasive held in a ceramic body, such as an oilstone or grinding wheel, the tougher aluminous grains stand up under the shearing action of the test piece longer than the brittle carbide of silicon abrasives. The tougher abrasive grains maintain their cutting edges and remain sharp longer than the brittle abrasives, which soon dull over, become glazed and stop cutting.

An examination of the curves in the paper shows that there is no great variation in the initial rate of cutting of any of the abrasives when tried under similar conditions. Any such slight variation might well be caused by a microscopic change in test conditions. Even with the utmost care it is almost impossible to obtain identical conditions in such a test. The wide variation in results obtained in wet and dry lapping or from charging the laps by rubbing or rolling shows the wide limit of the possible results that might be obtained. In testing solid abrasive wheels, the same wide variations are experienced with wet and dry grinding, slight variations in pressure, method of preparing the grinding surface (dressing the wheel) for test, the feeds and speeds used.

It is possible that the slight differences in the sizes of the abrasive grains obtained from the various manufacturers would have an influence on the results as the size of the holes in screens of a certain mesh varies according to the size of the wires used in the screen.

For lapping, a round solid grain which will stand up and maintain its shape is to be preferred to one which will break down and present new sharp cutting points to the work. Such a grain would cut the work being lapped, and in cutting would produce scratches which would be difficult to elminate.

Commercially only the abrasive flours, so-called, are employed for lapping, in general the size known as FF being the coarsest used. The diameter of a grain of FF averages 0.002 inches and the material is too fine to screen in the usual way. In order to obtain a uniform product, it is necessary to hydraulically classify the abrasive flours.

One of the largest small tool manufacturers in this country having experimented with all abrasives available for lapping found 65F alundum to be the fastest cutting abrasive material for his purpose. Cast iron laps are used with lard oil as a lubricant. The carbide of silicon flours were found to cut very fast, but at the same time it was impossible to eliminate scratches so deep that they could not be removed under commercial conditions. The amount of wear on the lap increased noticeably at the same time by the use of the carbide of silicon abrasive.

It would seem that, if carbide of silicon grain is more efficient than the aluminous abrasives in lapping hardened steel, then it would be more universally employed in place of the emery and alundum flours which seem to hold the field at present. It may be that the action of loose abrasive grain is materially different than when held in a body; however the cases are few, in actual practice, where carbide of silicon is more efficient than alundum when working on materials of a high tensile strength. With this exception, the authors have shown the action of loose grain abrasives in the fine numbers to be similar to the coarser sizes when used in solid wheel form.

The amount of time and patience necessary to obtain data for this paper can only be appreciated by those who have been engaged along similar lines. Professor Knight and Mr. Case are to be commended for the care and detail shown in their paper.

# THE SURFACE CONDENSER

BY C. F. BRAUN, SAN FRANCISCO

Associate-Member

This paper analyzes the functions of the surface condenser, presents briefly the fundamental principles governing design, discusses rational ratings, and compares typical commercial designs.

The primary functions of a surface condenser are to reduce the back pressure on the exhaust side of a steam prime mover; to conserve and return to the steam generator, in the water of condensation, as many heat units as possible; and to remove air from the feed water, thus reducing pitting of boilers. In accomplishing these results the condenser must handle four separate fluids: steam, air (including other non-condensable vapors), water of condensation, and cooling or circulating water. As the desirable state of these several fluids is not the same, the problem at once becomes a complicated one. Briefly, the conditions to be approached are:

*Steam* should enter the condenser, be conducted freely to all parts with least possible resistance, reduced to the lowest practicable temperature (and consequently pressure) and converted into water.

*Air*, a non-conductor, should be rapidly cleared from the heat-transmitting surfaces, collected at suitable places, practically freed from entrained water and water vapor, and cooled to a low temperature for removal at minimum volume, with consequent least expenditure of mechanical energy.

*Condensate* should also be rapidly cleared from the heat transmitting surfaces, freed from air, collected at suitable points for removal, and returned to the steam generator at the maximum practical temperature.

*Circulating water* should pass through the condenser with least friction, deposit a minimum amount of precipitated chemicals or debris, and absorb a maximum amount of heat.

The main principle of design of the condenser is the transference of heat from the steam through the dividing surface to the cooling water. The transfer per unit of area or of size is a measure of the efficiency of the apparatus and is directly proportional to the temperature difference or head. The temperature of the water increases during its passage through the condenser, and that of the steam decreases; it is therefore necessary to obtain mean values for temperature differences. A simple arithmetic mean is not correct, but the following formula, developed mathematically by Grashof, has repeatedly been proven accurate and is almost universally adopted.

$$M = \frac{D_1 - D_2}{\log_e \frac{D_1}{D_2}} \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

where

$M$ = mean temperature difference

$D_1$ = temperature difference between fluids at beginning $= T\,S_1 - T\,W_1$

$D_2$ = temperature difference between fluids at end $= T\,S_2 - T\,W_2$

$T\,S_1$ = initial temperature of steam

$T\,S_2$ = final temperature of steam

$T\,W_1$ = initial temperature of circulating water

$T\,W_2$ = final temperature of circulating water

It is commonly assumed that $T\,S$ is constant throughout the condenser, by which this formula reduces to

$$M = \frac{T\,W_2 - T\,W_1}{\log_e \frac{T\,S - T\,W_1}{T\,S - T\,W_2}} \ldots\ldots\ldots\ldots [2]$$

Since the frictional drop through the steam space of a condenser is usually 0.5 in. or more, representing with high vacuums a temperature difference of say 10 deg. fahr., it is evident that the use of formula [2] for applying to large condensers data obtained on smaller ones, or for analyzing the performance of a condenser or various sections of a condenser, will lead to serious errors.

With any given set of temperature values the mean temperature difference can be varied in only one way, namely, by arrangement of heating surfaces. These must be such as to produce counter-current flow, the circulating water entering where the steam is coolest and leaving where it is hottest.

*Transfer of heat* through a unit of condenser tube area per unit of mean temperature difference was early recognized as varying greatly under different conditions, the most apparent variation being an increase with increase of water velocity. Many experimenters have carried out extensive and careful tests to determine values of this heat transfer and a common formula is $H = K\,V^{1/2}$. That such a formula is fundamentally incorrect and misleading is at once apparent when it is considered that certain resistances to heat flow, namely, that of the tube and that on the steam side of the tube, are practically constant and entirely independent of the water velocity.

*Resistance.* The transfer of heat produced by the temperature head is opposed by a total resistance $R$ which for analysis divides conveniently into the resistance $R_v$ on the vapor or steam side of the surface, the resistance $R_m$ of the metal walls of the surface, and the resistance $R_w$ on the cooling water side of the surface. A simple equation expressing heat transfer in useful terms may be written as follows:

$$R = \frac{M}{H}$$

in which

$H$ = number of heat units transferred per unit time

$M$ = mean temperature difference

$R$ = total resistance $= R_v + R_m + R_w$

Even with high steam pressures and with superheat, the total B.t.u. to be extracted by the condenser may safely be assumed as 1000, and it is convenient to adopt an arbitrary resistance unit such that

$$H = \frac{1000 \times M}{R} \text{ or } W = \frac{M}{R} \ldots\ldots\ldots [3]$$

in which

$H$ = B.t.u. per sq. ft. per hour

$M$ = mean temperature difference in deg. fahr.

$R$ = resistance per sq. ft. of surface

$W$ = pounds steam condensed per sq. ft. per hour.

The symbol $U$ will be used when $M$ is unity, so that $U$ = B.t.u. per sq. ft. per hour per deg. mean temperature difference. This resistance $R$ may also be expressed in terms of equivalent conductivity by the equation

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Presented at the Spring Meeting of the Society, June 1915. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

$$R = \frac{1000 \times L}{C \times 4290}$$

in which

$L$ = thickness of substance in inches

$C$ = conductivity in c.g.s. units.

The paper here considers the deduction of the resistances $R_m$, $R_v$ and $R_w$ and how they are influenced by design and by factors of operation, such as coatings of oil, air and scale, upon the condenser surfaces.

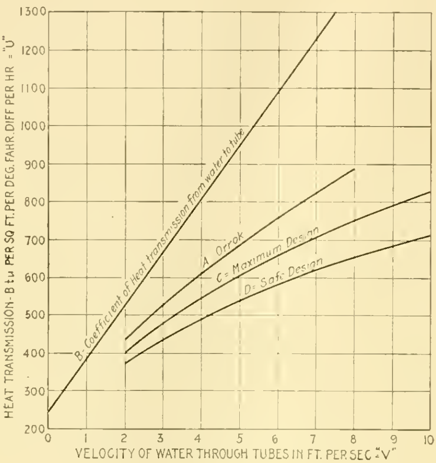


Fig. 1 Heat Transmission—Velocity Curves

The writer believes that the results of the tests by Orrok[1] (Fig. 1. Curve $A$) provide the most reliable data available on heat transfer through condenser tubes. In Fig. 2 (curve $A$) are plotted total resistances $R$ obtained by applying the values from Orrok's curve in Fig. 1 to equation [3], in which $M$ is taken as unity. For convenience, these resistances are plotted against reciprocal velocity instead of against velocity.

The paper shows that for ideal conditions $R_v = 0.333$ and that for a No. 18 gage brass tube $R_m = 0.044$, making $R_v + R_m = 0.333 + 0.044 = 0.377$, and it is reasonable to assume that Orrok's tests approach these conditions sufficiently closely so that a reasonable value to accept for $R_v + R_m$ for his tests is 0.4. On this assumption curve $B$, Fig. 2, is plotted showing the relation of $R_w$ to the reciprocal velocity.

A curve, Fig. 1 ($B$), plotted from the values on curve ($B$), Fig. 2, represents the relation of heat transfer from the surface of a condenser tube to velocity of the water in contact with that surface. From this curve $U_w$ varies directly with $V$ according to the equation

$$U_w = 245 + 141\ V.$$

This variation of resistance, inversely with velocity, is due to the fact that the particles of water in contact with the surface at any instant form a non-conductor which prevents the flow of heat from particles in the body of the water to the surface of the tube. The transfer of heat is really by convection, and the more rapid the removal of the heated particles and their replacement by cooler ones, the greater the heat transfer. With the same velocity this transfer of particles is much more rapid in a small tube than a large one, where, so to speak, a cold core of water exists. This indicates the desirability of small tubes and experience dictates $\frac{3}{4}$ in. to $\frac{7}{8}$ in. inside diameter as a maximum.

For apparent reasons of economical construction most condensers consist of a cylindrical shell containing closely-spaced round tubes. The water may pass through the tubes and the steam around them, or vice versa. While the steam circulates automatically as a result of condensation, the water moves only sluggishly due to slight change of gravity with change of temperature. The arrangement, therefore, of passing the water through the tubes, is invariably employed, thus making it possible to give the water a rapid positive movement.

Among metals commercially available for use in condenser tubes, copper has the highest conductivity and when properly alloyed, is less subject to corrosion than most others, thus permitting the use of thinner surfaces. Hence practically all condenser tubes are copper or high percentage copper alloy.

The size of tube is a determining factor in the thickness, larger tubes requiring greater thickness for mechanical strength, and from this viewpoint also small tubes are desirable.

The arrangement of heating surfaces for easy cleaning and the construction of water channel covers independent of pipe connections is important, although frequently neglected.

To prevent the formation of a coating of oil which has an effect more serious than a coating of scale, a fairly high steam velocity must be maintained over the tubes, and corners which become stagnant places must be eliminated.

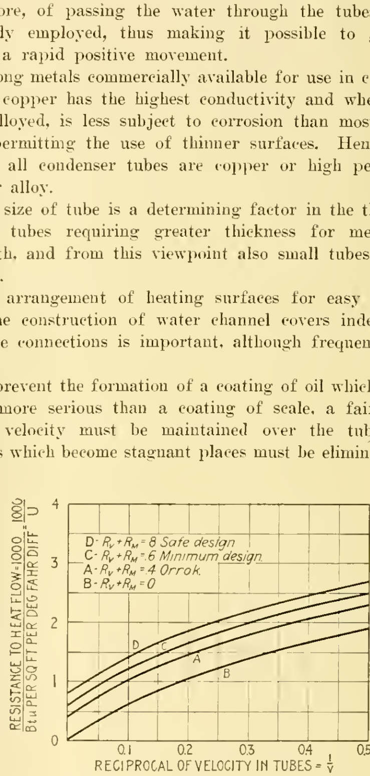


Fig. 2 Resistance—Reciprocal Velocity Curves

The paper here considers typical designs of condensers, pointing out their advantages and defects.

An exhaust opening of liberal size with a dome extending the length of the shell, Figs. 11 and 14, will cause the steam to be distributed to the ends of the tubes and prevent stagnant corners such as represented by the shaded portions in Figs. 3, 4 and 5.

Baffle plates for directing the steam to remote parts of the condenser introduce resistance to steam flow and should be avoided, except for the small plate directly in front of the exhaust inlet to protect the tubes from entrained water in the exhaust.

[1] Transmission of Heat in Surface Condensation, Geo. A. Orrok, Trans. Am. Soc. M. E., Vol. 32, page 1139.

The steam passing over the tubes condenses and diminishes in volume as it progresses, and hence in ordinary condensers the steam flow velocity rapidly decreases and becomes practically nil in the portion away from the inlet, permitting air to stagnate. This steam flow velocity may be maintained by constructing a gradually reducing steamway, a triangle with steam entering over one entire side, Fig. 6, being theoretically correct, or by gradually reducing the pitch of the tubes or by making lanes or passages to various parts of the steam space by omitting tubes, Figs. 11 and 14. Any one of these methods properly applied should be effective and result in good steam distribution at uniform velocities, prevent the stagnation of air at any point, and minimize the frictional drop.

Fig. 10 shows a commercial form of condenser which, however, has a shell of a shape that is somewhat inconvenient to construct. Fig. 9 shows similar taper passages embodied in a round shell, but the large heavy baffle plates which occupy the available tube space are objectionable. Fig. 7 shows this feature also, but the shape of the shell and the resistance to steam flow make it an unpractical construction. The design in Fig. 8 likewise has too many baffles which increase the weight and obstruct the steam flow. The design in Fig. 14 approaches that of the others in principle, but the shape of the water passages is objectionable; when a condenser is incorporated in the base of a turbine, these lanes should start from opposite the buckets as nearly as possible.

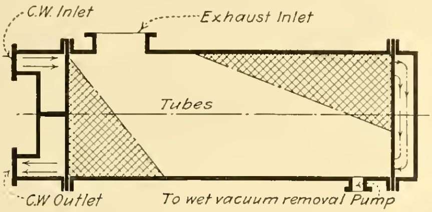


Fig. 3 Condenser Illustrating Incorrect Parallel Flow, Incorrect Water Connections, and Narrow Water Channels

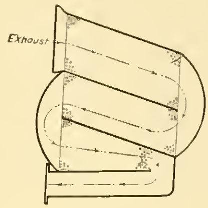


Fig. 7 Taper Passage Condenser, Illustrating Restricted Steamway and Uncommercial Shaped Shell

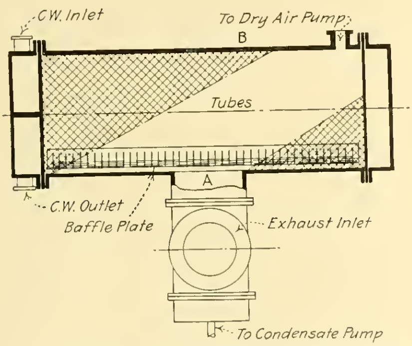


Fig. 4 Condenser Showing Effect of Excessive Baffling, and Improperly Located Air Connections

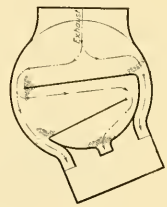


Fig. 8 Taper Passage Condenser, Illustrating Restricted Steamway

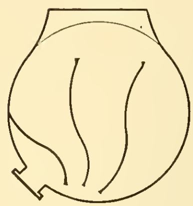

Fig. 9 Round Shell Condenser, Baffled to Have Three Taper Passages

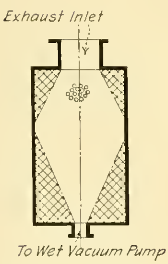


Fig. 5 High Rectangular Condenser

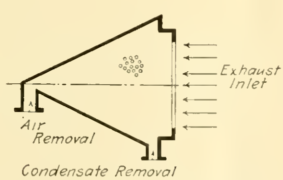


Fig. 6 Theoretically-Correct Condenser Shape

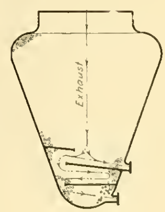


Fig. 10 Modern English Taper Passage Condenser

If a liberal pitch be employed for the tubes, and ample lanes be provided, the frictional drop, even through a large condenser, need not exceed 0.4 in. and less in smaller ones. Figs. 11, 13 and 14 show proper distribution, but Figs. 4, 7, 8, and 12, having long steamways and closely pitched tubes, may have frictional drops as great as 2 in.

It is important that a sufficient number of air removal connections be located at points where air accumulates (Fig. 11).

The quantity of air allowed to enter a condenser should at all times be minimized and the importance of tight joints and pipe connections should be impressed upon operators. As only a very small quantity can enter with the feed water, it is evident that proper operating attention to the tightness of condenser shell, low-pressure stages of the turbine, piping and valves, will reduce the air in the condenser to a very low figure. If a large quantity of air were present in a condenser, it could be detected by vacuum and temperature readings taken at the same part of the steam space, the temperature indicated being that of the vapor, and the pressure that of the sum of the pressures of the vapor and of the air.

In order to determine the completeness of the distribution of the steam to all parts of the steam space, the writer has computed the coefficient of heat transmission $U$ for each pass for two large condensers and has found this coefficient for the first pass only about 10 per cent. less than for the second, indicating that with proper steam distribution and effective air removal the value of $U$ will be about the same for all parts of the surface. If, however, steam distribution is poor and the clearing away from the surfaces and the removal of the air unsatisfactory, the value of $U$ for the first pass may be only 50 per cent. of that in the second. In a like manner, if the tubes away from the center are not doing their proportion of work, this will be indicated by the temperature readings taken on the water flowing from them.

The resistance on the water side of the condenser could be eliminated if very high water velocities through exceedingly small tubes could be used. This, however, would cause a rapid increase of frictional resistance and consequent cost of pumping, erosion of the tubes if the water contained sand, and an undesirable number of passes or a very long condenser. For these reasons a velocity flow is ordinarily limited to about 4 to 6 ft. per second. Experience shows 1 in. outside diameter to be the lower limiting size of tubes and this allowable only in very large condensers having a high circulating water ratio. Frictional loss may be minimized by using long tubes and fewer passes, reducing water passage and tube entrance loss.

Even distribution of water through all tubes is important and narrow channels causing high velocities, Figs. 3 and 4, or inlets directing water onto the tubes, Fig. 3, must be avoided, since uneven distribution is sure to result, those tubes not in the stream line receiving little water and being therefore largely ineffective.

Curve $C$, Fig. 1, is arrived at by accepting a coefficient of heat transmission $U$, of say 550, for a water velocity of 4 ft. per sec. This coefficient is about the best obtainable in practice and there are considerable data available for this water velocity. By comparing this with the valve on curve $B$, Fig. 1, the value of $R_v+R_m$ is determined as say 0.6, which is used in plotting the points on curve $C$, Fig. 2. Perhaps in most cases a value of 0.8 for $R_v+R_m$, giving curve $D$, would be safer to use for design. If we accept 4 as a desirable water velocity we obtain from curve $D$, Fig. 2, $R = 2$, corresponding to an allowable value for $U$ of say 500 B.t.u.

There follows in the paper a consideration of condenser design with reference to desirable temperature conditions and methods of removal from the condenser for each of the four fluids.

Steam must be maintained at the lowest practicable pressure, and hence the temperature must approach closely that of the circulating water discharge. There must be a difference, however, in order to produce heat flow; this should be kept within 10 deg. fahr.

Air must be removed from the condenser by a mechanical pump, the energy required for operation being directly proportional to the volume of air moved. This volume

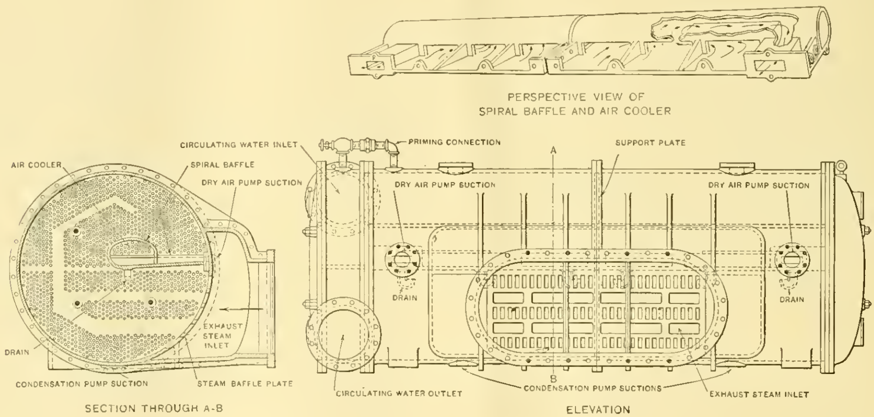


Fig. 11 Well-Designed Cylindrical Condenser

should be minimized by causing the air finally to pass over the coldest tubes.

The curves, Fig. 15, show the enormous effect, upon the volume of air mixed with saturated water vapor, of the partial pressure of the steam as indicated by the temperature. Thus, with a vacuum of 28 in. (2 in. absolute) corresponding to a steam temperature of 101 deg. fahr., 1 lb. of air, for a temperature of the mixture of 95 deg. fahr. corresponding to a partial steam pressure of 1.6 in. will have a volume of say 1200 cu. ft.; whereas if the partial pressure of the steam is reduced to 1 in. absolute, bringing the temperature of the mixture to 80 deg. fahr., this volume will be only 400 cu. ft. These figures indicate the importance of embodying in the condenser design an air cooler, especially in condensers with high vacuum.

Actual tests have proven that for ordinary wet vacuum pumps to handle the mixture of air, vapor, and water and maintain even moderately high vacuums it is necessary to cool the condensate 10 to 15 deg. below that due to the vacuum, which of course requires more circulating water and wastes more heat from the system. Another serious objection to the wet vacuum system is that compressing an emulsion of air and water is a most effective method of mixing the air with the condensate to return to boilers. Centrifugal air pumps having no clearance space, do not loose efficiency at high vacuums, and are rapidly coming into use, but the reciprocating type still has the advantage of requiring much less power for operation.

*Condensate should be removed at a high temperature.* Especially in large condensers, a number of condensate removal connections should be provided on the shell to insure free and quick flow to the removal pump, generally a centrifugal which, unlike a plunger pump, will handle varying quantities without speed changes, and which if properly vented never becomes vapor-bound.

*Circulating water,* to reach minimum quantity, must have an exit temperature closely approaching the steam temperature. The great effect of a comparatively small variation in this temperature may be appreciated by considering the maintenance of a 29 in. vacuum (79 deg. fahr.) with circulating water at 60 deg. fahr., the quantity required being twice as much if heated to within 14 deg. of the steam temperature, than if heated to within 9 deg., and the energy required to pump the circulating water being 8 times as much.

The optimum amount for this minimum temperature difference is always a compromise between condenser cost and pump and pumping cost, but with well designed apparatus should not exceed 10 deg. fahr. With poor designs, especially those having parallel flow, this difference is sure to be 15 to 20 deg. fahr. For service with circulating water obtained from cooling towers or other expensive source it might be warrantable to have this difference as low as 5 deg. fahr.

Regarding general structural features, proper provision for accommodation of expansion strains is usually accomplished by securing tubes into the tube sheets with packings and ferrules; a more modern method is to expand the tube into one head and pack at one end only, thus eliminating one half the leak possibilities. The proper supporting of tubes to prevent sagging and cracking is important and supporting plates drilled true with the tube sheet should be located not more than 8 ft. apart. Shells should be made of cast iron, and not of steel, which is corroded by the gases contained in the steam, and water channels and covers should be separate castings so that tube ends may be readily exposed for cleaning without breaking pipe connections.

The connections between and relative location of condensers and auxiliaries are important factors in condenser efficiency, but in most cases are beyond the control of the manufacturer and consequently are neglected and are a common source of condenser trouble. The exhaust pipe, condensate piping and air pump piping should all be amply large, although the last is ordinarily much larger than necessary.

The surface condenser, like most other apparatus, is subject to irrational, meaningless, and misleading ratings, the most objectionable being square feet per engine horse power, on account of the wide variation in the amount of steam required per engine horse power, say 9 to 25 lb. per hour. The more common rating is pounds steam condensed per square foot, common marine practice being to allow 1 sq. ft. per 10 lb. of steam and to hope for a vacuum somewhere between 23 in. and 26 in.; this is little better as it does not consider even cooling water temperature which may range from say 40 to 80 deg. fahr. A comprehensive rating must include the following:

(*a*) Quantity of steam condensed.
(*b*) Vacuum obtainable (corrected to 30 in. barometer).
(*c*) Temperature of available cooling water.
(*d*) Cooling water exit temperature.
(*e*) Condition of air at point of removal.
(*f*) Friction head on cooling water.
(*g*) Temperature of condensate at point of removal.

The first four items express the heat transmitting efficiency

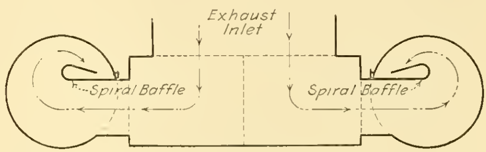


Fig. 12 Base and Double Wing Condenser, Illustrating Excessively Long Steamway

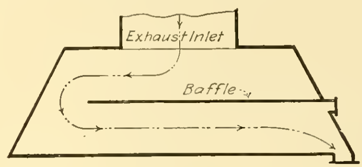


Fig. 13 Base Condenser with Taper Passage

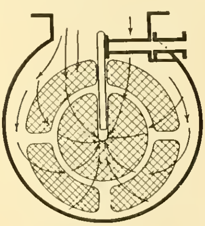

Fig. 14 Condenser Giving Taper Passage Effect without Baffles

and can for purposes of comparison be reduced to B.t.u per sq. ft. per deg. difference per hour.

Since a higher vacuum at the air pump than at the exhaust inlet is of no value, the mean temperature difference used for comparing results on condensers should be computed, on the assumption that the steam temperature

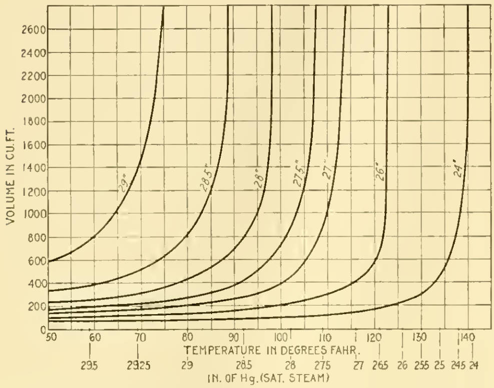


Fig. 15 Curves Showing the Volume per Pound of Air Mixed with Saturated Water Vapor, for Various Temperatures and Pressures of the Mixture

throughout the condenser is that due to the vacuum at the exhaust inlet and equation [2], the values for which can be determined from the chart, Fig. 15, should be used.

Fig. 16 is a diagram for the rapid determination of mean temperature difference values. Probably the most reliable formula for determining these is that of Grashof which when the temperature of one of the mediums is constant, reduces to

$$D = \frac{T_2 - T_1}{\log_e \dfrac{T_s - T_1}{T_s - T_2}}$$

where $D$ equals the mean temperature difference, $T_1$ the lowest temperature of the fluid, $T_2$ the highest temperature of the fluid, $T_s$ the temperature of the gas. The result will not be changed if any constant be deducted from all of the $T$'s in the equation. By making this constant $T$ the equation is simplified to one of three variables, which are plotted on the diagram, Fig. 16. To increase the accuracy or range of the diagram two scales are given; for temperatures between 200 deg. and 1000 deg. use the 100 scale. Five curves showing pressure-heat-temperature relations of steam are produced on the same set for convenient reference.

The complete equation for the condenser is

$$S = \frac{W \times Q}{M \times U} \text{ or } U = \frac{W \times Q}{M \times S}$$

in which

$U$ = B.t.u. per sq. ft. per deg. fahr. difference per hour.
= coefficient of heat transmission.
$M$ = Mean temperature difference in deg. fahr.
$W$ = Pounds steam condensed per hour.
$S$ = Square feet of cooling surface.
$Q$ = Total heat removed by circulating water per pound steam condensed (usually taken as 1000 in all cases for simplicity).

Thus for example, assuming results as follows from two condensers, we can say that A is 50 per cent. more efficient than B.

| | A | B |
|---|---|---|
| Square feet surface | 2000 | 5500 |
| Pounds steam condensed per hour | 18500 | 57200 |
| Vacuum | 28½ in. (1½ in. abs.) | 27 |
| Temperature entering cooling water | 65 | 60 |
| Temperature exit cooling water | 80 | 100 |
| Mean temperature difference per equation [1] | 18.3 | 30.9 |
| B.t.u. per sq. ft. per deg. difference per hour | 505 | 337 |

Items 3 to 6 determine the mechanical energy required by air condensate and circulating pumps. Item 7 indicates the heat efficiency, being a measure of the heat returned to the system in the condensate.

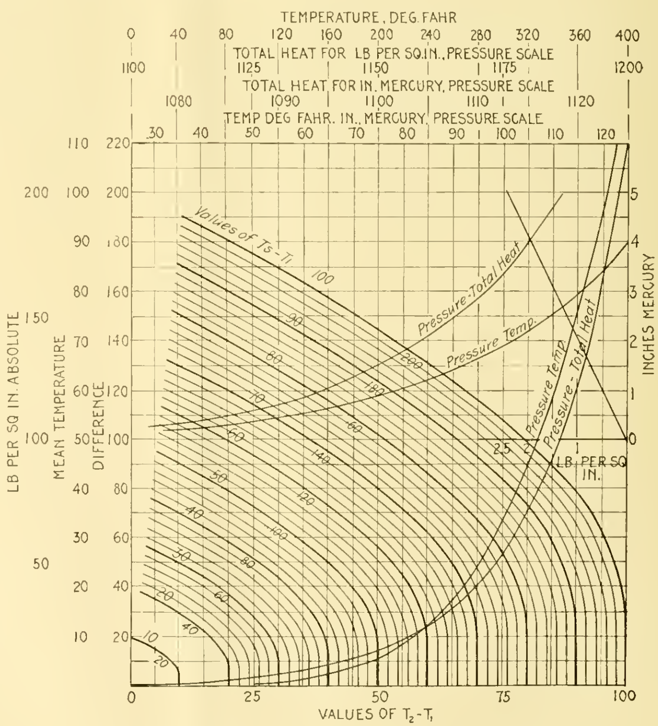


Fig. 16 Curves for Solution of Equation [2]

## DISCUSSION

P. E. Reynolds (written). A few years back it appeared to be the main idea of the designer to crowd as much cooling surface as possible into the least space, regardless of accessibility of the surface to the steam, or the friction loss entailed in bringing the steam to the surface.

There is no doubt that large exhaust openings, combined with steam distributing domes of ample dimensions and steam lanes or passages through the tubes, are some of the main features of efficient surface condensers designed to maintain high vacua.

Regarding the variations of heat transfer with water velocity, although Mr. Braun may be theoretically correct in stating that Mr. Orrok's exponential formula is fundamentally wrong, since the resistance to heat transfer of the tube itself and that on the steam side of the tube are constant, yet it seems that since these resistances are constant it is a useless complication for all practical conditions of condenser designs to take them into consideration.

Regarding parallel flow and counter-current condensers, I agree with Mr. Braun that the latter give the best results; however, Mr. Braun's proof of the fact by means of the general formula

$$M = \frac{D_1 - D_2}{\log_e \dfrac{D_1}{D_2}}$$

for the logarithmic mean temperature difference I do not consider correct. It is my understanding that in the mathematics involved in the derivation of this formula, the assumption is made that the heat absorbed by the cooler fluid results in a corresponding decrease in temperature of the hotter fluid. As these conditions do not prevail in a steam condenser, since the steam temperature is not decreased by the abstraction of heat at constant pressure, I would not consider that this formula could be correctly applied.

The formula:

$$M = \frac{TW_2 - TW_1}{\log_e \dfrac{TS - TW_1}{TS - TW_2}}$$

based on the assumption that the steam temperature $T\ S$ is constant throughout the condenser, is the only one that can be correctly used. However, it appears that too much weight should not be attached to the mean temperature as given by this formula, since the assumptions on which its mathematics is based are not fulfilled in actual surface condensers, and if a true mean temperature difference between the cooling water and steam is desired, it is probable that the arithmetical mean is as nearly correct as any.

H. Wade Hibbard mentioned that in the author's reference to the exhaust pipe between the engine and condenser he would suggest adding that in some installations it is desirable to use a steam separator to remove the water from the exhaust steam before it goes to the condenser.

The Author. Referring to the remarks of Professor Hibbard, who suggests that it may be desirable to have a steam separator between the prime mover and the condenser, I will assume that he thinks it advisable to remove the water from the exhaust steam so as to reduce the coating of condensate which will adhere to the condenser tubes. This has been tried many times, and very elaborately by one or two manufacturers, that is, by the installing of drain plates, which might be called separators, in the condenser; and it has been invariably found that these will offer resistance to the flow of steam, besides complicating and increasing the cost of the design, which more than offset any possible value that they might have in increasing the heat transfer by reason of decreasing the resistance on the steam side of the tube, and I feel sure that this is now an established fact.

Replying to Mr. Reynolds' remarks, I must point out some obvious fallacies.

His statement that the resistance $R_v$ on the steam side of the tube, and the resistance $R_m$ of the tube are, in condensers, nearly constant, does not agree with facts.

Actually, $R_v$ varies greatly with varying amounts of air present, as is plainly apparent when one considers the marked effect upon vacuum produced by even the most minute of air leaks. Furthermore, repeated tests on two-pass condensers, from which the performances of each half the condenser has been computed separately, have invariably shown that the coefficient of heat transfer is less in that half which contains the air outlets.

$R_m$, which properly includes the resistance of *any solids adhering to the tube,* increases greatly, as we all well know, when the condenser becomes foul with scale or oil, and the value to be given it should depend upon the quality of the circulating water, the presence or absence of oil in the exhaust and the continuity of service required.

Mr. Reynolds' limitation of the logarithmic mean temperature difference formula is also incorrect. The only assumption involved in the mathematical derivation is the proportionality of heat transmitted to the first power of the temperature difference. This proportionality is not absolutely true in a commercial condenser, due to the presence of air, but it is certainly more desirable to start with rational and the theoretically correct formula, making allowances in practical design for known influencing factors, than to revert to rule of thumb methods and accept formulæ such as the arithmetical mean for temperature difference which we know to be fundamentally wrong. To fulfill Mr. Reynolds' conditions for the correctness of formula [1] it is only necessary to consider the steam as a fluid having an infinitely large specific heat.

# THE RELATION BETWEEN PRODUCTION AND COSTS

BY H. L. GANTT, NEW YORK

Member of the Society

*Mr. Gantt's paper at the Spring Meeting drew out a large amount of discussion, which is here reported nearly in full. The paper contends that, whereas it has been common practice to make the products of a factory running at a portion of its capacity bear the whole expense of the factory, the only expense logically chargeable to a product is that needed for its production when the factory is running at its full or normal capacity. The expense of any portion of a plant not needed in production is a business expense to be deducted from profits, or entered as a loss if the profits will not cover it. The determination of the expense required for normal operation is primarily an engineering problem, instead of an accounting problem, and the cost accountant of the future must himself be an engineer.*

MANUFACTURERS in general recognize the vital importance of a knowledge of the cost of their product, yet but few of them have a cost system on which they are willing to rely under all conditions.

While it is possible to get quite accurately the amount of material and labor used directly in the production of an article, and several systems have been devised which accomplish this result, there does not yet seem to have been devised any system of distributing that portion of the expense known variously as indirect expense, burden or overhead, in such a manner as to make us have any real confidence that it has been done properly.

There are in common use several methods of distributing this expense. One is to distribute the total indirect expense, including interest, taxes, insurance, etc., according to the direct labor. Another is to distribute a portion of this expense according to direct labor, and a portion according to machine hours. Other methods distribute a certain amount of this expense on the material used, etc. Most of these methods contemplate the distribution of *all* of the indirect expense of the manufacturing plant, however much it may be, on the output produced, no matter how small it is.

If the factory is running at its full, or normal, capacity, this item of indirect expense per unit of product is usually small. If the factory is running at only a fraction of its capacity, say one-half, and turning out only one-half of its normal product, there is but little change in the total amount of this indirect expense, all of which must now be distributed over half as much product as previously, each unit of product thereby being obliged to bear approximately twice as much expense as previously.

When times are good, and there is plenty of business, this method of accounting indicates that our costs are low; but when times become bad and business is slack, it indicates high costs due to the increased proportion of burden each unit has to bear. During good times, when there is a demand for all the product we can make, it is usually sold at a high price and the element of cost is not such an important factor. When business is dull, however, we cannot get such a high price for our product, and the question of how low a price we can afford to sell the product at is of vital importance. Our cost systems, as generally operated at present, show under such conditions that our costs are high and, if business is very bad, they usually show us a cost far greater than the amount we can get for the goods. In other words, our present systems of cost accounting go to pieces when they are most needed. This being the case, many of us have felt for a long time that there was something radically wrong with the present theories on the subject.

As an illustration, I may cite a case which recently came to my attention. A man found that his cost on a certain article was 30 cents. When he found that he could buy it for 26 cents, he gave orders to stop manufacturing and to buy it, saying he did not understand how his competitor could sell at that price. He seemed to realize that there was a flaw somewhere, but he could not locate it. I then asked him what his expense consisted of. His reply was labor 10 cents, material 8 cents, and overhead 12 cents. My next question was: Are you running your factory at full capacity? I got the reply that he was running it at less than half its capacity, possibly at one-third. The next question was: What would be the overhead on this article if your factory were running full? The reply was that it would be about 5 cents; hence the cost would be only 23 cents.

The possibility that his competitor was running his factory full suggested itself at once as an explanation.

The next question that suggested itself was how the 12 cents overhead, which was charged to this article, would be paid if the article was bought. The obvious answer was that it would have to be distributed over the product still being made, and would thereby increase its cost. In such a case it would probably be found that some other article was costing more than it could be bought for; and, if the same policy were pursued, the second article should be bought, which would cause the remaining product to bear a still higher expense rate.

If this policy were carried to its logical conclusion, the manufacturer would be buying everything before long, and be obliged to give up manufacturing entirely.

The illustration which I have cited is not an isolated case, but is representative of the problems before a large class of manufacturers, who believe that *all of the expense, however large, must be carried by the output produced, however small.*

This theory of expense distribution is quite widespread, and clearly indicates a policy, which in dull times would, if followed logically, put many of our manufacturers out of business. In 1897 the plant of which I was superintendent was put out of business by just this kind of logic. It never started up again.

Presented at the Spring Meeting of the Society, June 1915. Complete paper may be obtained without discussion; price 5 cents to members; 10 cents to non-members.

Fortunately for the country, American people as a whole will finally discard theories which conflict with common sense; and, when their cost figures indicate an absurd conclusion, most of them will repudiate the figures. A cost system, however, which fails us when we need it most, is of but little value and it is imperative for us to devise a theory of costs that will not fail us.

Most of the cost systems in use, and the theories on which they are based, have been devised by accountants for the benefit of financiers, whose aim has been to criticize the factory and to make it responsible for all the shortcomings of the business. In this they have succeeded admirably, largely because *the methods used are not so devised as to enable the superintendent to present his side of the case.*

Our theory of cost keeping is that *one of its prime functions is to enable the superintendent to know whether, or not, he is doing the work he is responsible for as economically as possible,* which function is ignored in the majority of the cost systems now in general use. Many accountants, who make an attempt to show it, are so long in getting their figures in shape that they are practically worthless for the purpose intended, the possibility of using them having passed.

In order to get a correct view of the subject we must look at the matter from a different and broader standpoint. The following illustration seems to put the subject in its true light:

Let us suppose that a manufacturer owns three identical plants, of an economical operating size, manufacturing the same article,—one located in Albany, one in Buffalo and one in Chicago,—and that they are all running at their normal capacity and managed equally well. The amount of indirect expense per unit of product would be substantially the same in each of these factories, as would be the total cost. Now suppose that business suddenly falls off to one-third of its previous amount and that the manufacturer shuts down the plants in Albany and Buffalo, and continues to run the one in Chicago exactly as it has been run before. The product from the Chicago plant would have the same cost that it previously had, but the expense of carrying two idle factories might be so great as to take all the profits out of the business; in other words, the profit made from the Chicago plant might be offset entirely by the loss made by the Albany and Buffalo plants.

If these plants, instead of being in different cities, were located in the same city, a similar condition might also exist in which the expense of the two idle plants would be such a drain on the business that they would offset the profit made in the going plant.

Instead of considering these three factories to be in different parts of one city, they might be considered as being within the same yard, which would not change the conditions. Finally, we might consider that the walls between these factories were taken down and that the three factories were turned into one plant, the output of which had been reduced to one-third of its normal volume. Arguing as before it would be proper to charge to this product only one-third of the indirect expense charged when the factory was running full.

If the above argument is correct, we may state the following general principle: THE INDIRECT EXPENSE CHARGEABLE TO THE OUTPUT OF A FACTORY BEARS THE SAME RATIO TO THE INDIRECT EXPENSE NECESSARY TO RUN THE FACTORY AT NORMAL CAPACITY, AS THE OUTPUT IN QUESTION BEARS TO THE NORMAL OUTPUT OF THE FACTORY.

This theory of expense distribution, which was forced upon us by the abrupt change in conditions brought on by the war, explains many things which were inexplicable under the older theory, and gives the manufacturer uniform costs as long as the methods of manufacture do not change.

Under this method of distributing expense there will be a certain amount of undistributed expense remaining whenever the factory runs below its normal capacity. A careful consideration of this item will show that it is not chargeable to the product made, but is a business expense incurred on account of our maintaining a certain portion of the factory idle, and chargeable to profit and loss. Many manufacturers have made money in a small plant, then built a large plant and lost money for years afterwards, without quite understanding how it happened. This method of figuring gives a clear explanation of that fact and warns us to do *everything possible to increase the efficiency of the plant we have, rather than to increase its size.*

This theory seems to give a satisfactory answer to all the questions of cost that I have been able to apply it to, and during the past few months I have laid it before a great many capable business men and accountants. Some admitted that this viewpoint would produce a very radical change in their business policy, and are already preparing to carry out the new policy.

It explains clearly why some of our large combinations of manufacturing plants have not been as successful as was anticipated, and why the small, but newer plant, is able to compete successfully and make money, while the combinations are only just holding their own.

The idea so prevalent a few years ago, that in the industrial world money is the most powerful factor, and that if we only had enough money, nothing else would matter very much, is beginning to lose its force, for it is becoming clear that *the size of a business is not so important as the policy by which it is directed.* If we base our policy on the idea that the cost of an article can only legitimately include the expense necessarily incurred either directly or indirectly in producing it, we shall find that our costs are much lower than we thought, and that we can do many things which under the old method of figuring appeared suicidal.

The view of costs so largely held, namely, that *the product of a factory, however small, must bear the total expense, however large,* is responsible for much of the confusion about costs and hence leads to unsound business policies.

If we accept the view that the article produced shall bear only that portion of the indirect expense needed to produce it, our costs will not only become lower, but relatively far more constant, for the most variable factor in the cost of an article under the usual system of accounting has been the "overhead," which has varied almost inversely as the amount of the product. This item becomes substantially constant if the "overhead" is figured on the normal capacity of the plant.

Of course a method of accounting does not diminish the expense, but it may show us where the expense properly belongs, and give us a more correct understanding of our business.

In our illustration of the three factories, the cost in the Chicago factory remained constant, but the expense of supporting the Buffalo and Albany factories in idleness was a charge against the business, and properly chargeable to profit and loss.

If we had loaded this expense on the product of the Chicago factory, the cost of the product would probably have been so great as to have prevented our selling it, and the total loss would have been greater still.

When the factories are distinctly separate, few people make such a mistake, but where a single factory is three times as large as is needed for the output, the error is frequently made, with results that are just as misleading.

*As a matter of fact it seems that the attempt to make a product bear the expense of plant not needed for its production is one of the most serious defects in our industrial system to-day, and farther reaching than the differences between employers and employees.*

The problem that faces us is then first to find just what plant, or part of a plant, is needed to produce a given output, and to determine the "overhead" expense on operating that plant or portion of a plant. This is primarily the work of the manufacturer, or engineer, and only secondarily that of the accountant, who must, as far as costs are concerned, be the servant of the superintendent.

In the past, in almost all cost systems the amount of "overhead" to be charged to the product, when it did not include *all* the "overhead," was more or less a matter of judgment. According to the theory now presented, it is not a matter of judgment, but can be determined with an accuracy depending upon the knowledge the manufacturer has of the business.

Following this line of thought it should be possible for a manufacturer to calculate just what plant and equipment he ought to have, and what the staff of officers and workmen should be to turn out a given profit.

If this can be correctly done, the exact cost of a product can be predicted. Such a problem cannot be solved by a cost accountant of the usual type, but is primarily a problem for an engineer, whose knowledge of materials and processes is essential for its solution.

Having made an attempt to solve a problem of this type, one of the most important functions we need a cost system to perform, is to keep the superintendent continually advised as to how nearly he is realizing the ideal set, and to point out where the shortcomings are.

Many of us are accustomed to this viewpoint when we are treating individual operations singly, but few have as yet made an attempt to consider that this idea might be applied to a plant as a whole, except when the processes of manufacture are simple and the products few in number. When, however, the processes become numerous or complicated, the necessity for such a check becomes more urgent, and the cost keeper who performs this function becomes an integral part of the manufacturing system, and acts for the superintendent, as an inspector, who keeps him advised at all times of the quality of his own work.

This conception of the duties of a cost keeper does not at all interfere with his supplying the financier with the information he needs, but insures that information shall be correct, for the cost keeper is continually making a comparison for the benefit of the superintendent, of what has been done with what should have been done. Costs are valuable only as comparisons, and comparisons are of little value unless we have a standard, which it is the function of the engineer to set.

Lack of reliable cost methods has, in the past, been responsible for much of the uncertainty so prevalent in our industrial policies; but with a definite and reliable cost method, which enables us to differentiate between what is lost in manufacturing and what is lost in business, it will usually become easy to define clearly the proper business policy.

## DISCUSSION

In presenting his paper at the meeting the author introduced it with the following remarks:

I was moved to present this paper not because the ideas were absolutely new, but because they are of such great importance to manufacturers, and are apparently so little understood by many of them.

Since publishing this paper I have had my attention called to the work of numerous accountants, and especially manufacturers, who, within the last few years, have discarded tradition, and made excellent progress toward a rational system of expense distribution. Some have apparently solved the problem completely. Nevertheless it is a fact that the generally accepted theory of only a few years ago, was that the product of a shop must bear the total expense of owning and operating that shop. It is also a fact that this theory is still misguiding many manufacturers. In addition, the expense of selling was often added as a part of the cost of the article.

The first step taken by students of this problem was to separate the cost of manufacturing from that of selling. According to this division, the expense of manufacturing stops when the article is delivered to the shipping department or placed in the finished stock room. All expenses incurred from this time on belong to the sales department and are deductions from profits.

This separation took one variable and confusing element out of the manufacturing cost; but with a widely varying product and a relative fixed "burden" or "overhead" charge, the manufactuirng cost was still subject to fluctuations over which the superintendent had no control, and hence not only gave no measure of the efficiency with which the shop was run, but was no guide at all to the salesman; and was actually misleading when business was dull.

The next step in the evolution of a rational cost system was to establish a fixed "overhead" based on past experience. This had the great advantage of making costs comparable, and of giving the salesman a definite limit by which to be governed.

It had the disadvantage that if the output was at a less rate than the usual previous rate, there was left unabsorbed a portion of this "overhead;" and vice versa, if the product was greater than at the previous average rate more "overhead" was accounted for than was actually incurred. Of the various methods adopted to take care of this residual "overhead," the two that are best known are, first by charging it to a fund that is eventually charged back on the cost of the product, and second by charging it directly to business as a profit or loss. The second method seems the most logical of the two, and for those who are guided only by what has been done in the past, seems to be entirely satisfactory. Indeed for him who is an accountant only, and not familiar with

manufacturing methods, it is apparently the only possible solution.

To the engineer, however, who is not so much concerned with *what has been done* as with *what should be done,* it is not at all satisfactory.

If a plant has been built that is larger than is needed to supply the available market, the business error of building the excess portion of that plant should not be charged as a manufacturing cost, but directly to the business as a loss. For instance, if we should build two identical plants where only one was needed, the expense of owning and maintaining one of them in idleness could not be charged to the goods manufactured in the other, but would have to be deducted from the profits of the business.

In the same way the expense of any portion of a plant not needed in production should not be charged to the articles produced, but is a business expense and must be deducted from profits, or entered as a loss, if the profits will not cover it. *In other words, the only expense logically chargeable to a product is that needed for its production when the factory is running at its full or normal capacity,* which may be quite different from that used in its production in the past.

Inasmuch as the determination of this fact is primarily an engineering or manufacturnig problem, and not primarily an accounting problem, it becomes evident that cost methods must be based on engineering knowledge, and the cost accountant of the future must himself be an engineer or manufacturer, or be guided by one.

Granting this, it is safe to predict the early dawning of the day longed for by Uncle John Sweet, when *the man who knows what to do and how to do it* shall gradually supplant *the man who knows what was done and who did it.*

D. B. Rushmore. Speaking entirely from an individual standpoint, I would say that all of my experience points to the fact that free industrial competition in general means nothing but final bankruptcy. This is because of certain elements of human nature which, for a great variety of reasons, allow business to be taken by someone below cost.

In figuring the cost of any product the largest and most indeterminate item is usually the overhead expense, and the proper use of this overhead after it is once obtained is of course the difficult part of the problem. The manufacture and production of power and commodities is usually subject to considerable fluctuations, and in the extreme case of a small power house for a widely fluctuating load, in which the power may vary from zero to a maximum over irregular intervals, the instantaneous cost of power will vary enormously. These fluctuations may be momentary, hourly or even annually, and the proper distribution of the overhead in order to determine the average cost is necessarily a problem requiring judgment.

The year has usually been taken as the unit of time. The question is, can this period be enlarged so as to include an average of several of the past years, and can these figures be used in an attempted prophecy of the future. It would certainly seem as if this were a feasible and sensible point of view.

Forrest E. Cardullo. I think the idea advocated in the paper is correct, but there are two points to which I would call attention: One is that the loss incurred and charged to profit and loss must be made up in the selling price. The other one is the question as to whether it is better to charge that loss annually against the product, or to capitalize it and get rid of it once and for all.

W. N. Polakov. The question is, whether the cost at which a product has been manufactured in the past is the cost at which this product shall be and can be manufactured. If the overhead is not properly differentiated from the cost of production; and if the cost of production is not known,—not as it was in the past, but as it ought to be,—we shall not be in a sound position.

To quote an example, there is an electric plant which carried \$200,000 overhead a year. The records show that the plant generated current at between 0.72 and 0.68 cent per kw., depending on the load factor.

If with an annual output of 60,000,000 kw-hr. (or about half capacity), the overhead charges were distributed per kw-hr., it would be $^1/_3$ cent; if the output were 80,000,000, the overhead would be $^1/_4$ cent and if there were a full output of 120,000,000, allowing a margin for peaks and breakdowns, the overhead would be 0.166 cent.

Consider at the same time that the capacity of the plant may not have been sufficient for the increased business and that a public utility company was willing to sell any amount of current for 0.83 cent per kw-hr. One would immediately, in accordance with the old method, go to the old records and get the lowest figure, 0.68 cent, for which current had been manufactured, and then add the minimum overhead of 0.166 cent, giving 0.85 cent instead of the 0.83 cent which the public service corporation offered. On this basis one would seem to be warranted in buying the current, at least for the present, because of the saving of 0.02 cent on every kw-hr. When new records are compiled, it would be found that the cost of production of the plant in question had risen to 0.91 cent because the output was reduced and the overhead was 0.25 instead of 0.166. We finally come to the point where we think there is no use of carrying our plant any longer, so it is shut down and all the power purchased outside at 0.83 cent.

If this were done it would mean that we would get the power at 0.83 cent, plus the overhead on the dead plant of \$200,000. In this case the cost per kw-hr. would be 0.996 cent, and we would then remember that while the plant was in operation current had been manufactured for 0.85 cent. Where would be the expected saving? It apparently was there,—it was on the books, but it appears to be lost. Where has it gone? One fallacy of such calculations is that we use the past records instead of the exact scientifically establishd standard of what the cost ought to be. In fact, in this case it ought to be only 0.4, as I know from actual experience that the cost was brought down in this plant from 0.72 to 0.44, which, added to the overhead even in accordance with the old method, would be only 0.6, consequently the expected saving of some \$25,000 on the plan of buying power would be turned into a loss for the company of over a quarter of a million dollars.

W. W. Bird. This paper is of special interest to me as it indicates in a way the evolution of the mechanical engineer. Twenty or thirty years ago we came to the meetings of this Society and we heard Thurston talk about the steam engine indicator. The mechanical engineer of those days made boiler and engine tests. Ten years ago we heard Taylor tell

about the stop watch and routing cards for workmen. The mechanical engineer of that period not only went into the power house of an industrial plant, but also into the shop. The engineering thought as expressed by the planning department was carried out in the shop just the same as the ideas as expressed by the blue prints from the drafting room were followed.

Now Gantt comes along and tells us that it is not good engineering to put all of the shop burden on productive labor all of the time. In other words, the mechanical engineer of today is applying the general principle of cause and effect in the office of our industrial plants the same as he has in the other departments.

At the Worcester Polytechnic Institute, we are working along these lines and our students have laboratory work in the office of our commercial shops just the same as they do in the steam and other laboratories.

Good engineering is needed in the accounting department and I am very glad that the author has presented this paper for our consideration. We ought to tackle this problem of shop burden the same as we would one in power transmission. Let productive labor carry that part of the burden for which it is responsible and can regulate, and let the men higher up do the same.

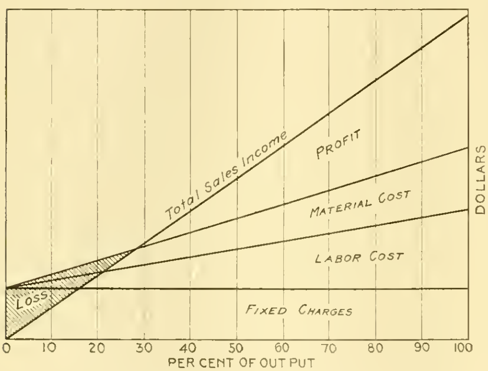


Fig. 1 Diagram showing Relation of Fixed Charges, Production Cost and Income

The responsibility of our manufacturing plants should not be divided. Starting from the top, responsibility should be delegated and definitely placed and then if a plant cannot be made a success, let the self executing laws of nature do their work and put the plant out of existence.

James A. White showed a diagram, Fig. 1, which he had found useful in determining the effect of fixed charges. Assuming that it is known what the fixed charges are, a line is drawn to represent them as indicated. Above are added lines to represent labor and material costs, which vary with the output. A fourth line represents sales income, which varies directly as the amount of business done, and starts at the zero point of the diagram. The point where the sales income line crosses the total cost line indicates where it is advisable to shut down the factory; the shaded space at the left indicating loss, and the upper space at the right, profit. This diagram is difficult to apply to a factory, but it is easy of application to such a concern as a gas company, whose fixed charges can be accurately determined.

## CONTRIBUTED DISCUSSION

Charles Piez. No matter to what degree of refinement a cost keeping system may be carried, costs are, at best, but fairly accurate approximations, and to be even that must represent averages over long periods. If the costs are to be used as the basis of selling quotations, they should be based on normal and not on exceptional conditions.

Too many manufacturers still sell at what they assume to be the market price, in the hope that ingenuity and rigid economy will let them out at a profit. But permanency in business will never be the lot of the manufacturer who permits the buyer to name the price and who does not fortify his position by a thorough knowledge of costs.

With the wide fluctuations to which manufacturing is unfortunately subjected, it is essential that a fairly accurate determination be made of what normal capacity, normal expense and therefore normal costs are; very few factories run uniformly at 100 per cent capacity; a great many vary in the course of a business cycle from 50 per cent capacity in times like the present, to 150 per cent capacity in boom times. Not only is there wide variation in total output, but departments frequently show great variations independent of general business conditions.

As a rule, a manufacturing enterprise whose business shows considerable fluctuation must have a capacity slightly in excess of the normal or average requirements if prompt service to the customer is necessary.

In our own business we have assumed normal output to be the output of each department secured by its full complement of men working 2500 hours per year which represents 90 per cent of the possible working hours per annum on a 54-hour week basis.

The average factory expenses are distributed on a pay roll representing this degree of activity and our average or standard departmental and general expense factors are based on the output which this degree of activity represents. Costs are based on the average factors, and are therefore fairly uniform and wholly independent of the fluctuations of business.

At the end of each month the standard or average factors are compared with the actual factors for each department and the total of all expenses is compared with the total obtained by distributing the standard rates. In times of depression the standard rates fail to distribute the total expenses and the debit balance goes to reduce the profits. When the business is running considerably above the assumed normal the standard factors produce a credit balance which goes to increase the profits.

The sheets showing the comparison between actual and standard expense rates, which the cost department submit to the management each month, keep the management informed and enable it to correct the standard rates when changed conditions render corrections advisable. By following the method of distributing expenses through carefully ascertained standard factors, we secure in a ready and practical way the results which the author advocates.

In this connection it might be well to point out the opportunity for a valuable service which the Society might render not only to its members, but to the manufacturing community

at large. The Society has the honor of having recommended several mechanical standards, which have had universal adoption. Would it not be wholly within its province to give the subject of expense distribution in mechanical plants some attention, and make recommendations for the standardization of such distribution?

There can be no real comparison of costs unless there is uniformity in cost accounting; neither will violent fluctuations in prices in times of depression cease until uniform and standardized systems of expense distribution take the determinations of costs out of the realm of conjecture and place it on a firm foundation of ascertained facts.

Frank H. Neely. This paper does much to clear up the uncertainty with which most manufacturers consider indirect expense and its application to costs. Further, it shows in clear relief the urgent need of the engineer in laying out and deciding upon the business issues of manufacturing.

In times such as we are just passing through, the idea of making money has to give way to the idea of the preservation of a working organization and of taking care of the workers who in good times past have helped make the profit, and who, if the author's idea is followed out, will have a great deal of work that would otherwise have gone to factories not so apparently loaded down with indirect expense.

About three years ago, in standardizing the processes in a factory making a complete line of candies and crackers, I found it necessary to develop my cost records very much along the line of the author's paper. This business is seasonal, and in the three fall months the volume is practically double what it is in any other similar period in the year.

This, of course, made the costs appear high in the first part of the year and extremely low in the busy season, which forced the standardization of costs on the lines described in the paper for the individual product; and each department, as the year progresses, shows its profit or loss, at the same time absorbing its just pro rata of indirect expense, regardless of the volume manufactured.

Sterling H. Bunnell. The reason why cost systems are generally of so little use to the manufacturer is that they are planned for no other purpose than to meet the needs of the accountant in balancing his books. The fact that cost keepers are accountants and not manufacturers is the only explanation of the belief so prevalent that the cost of the product of a given month is equal to the total expenditure of the month.

The fact is, that the cost of to-day's product is the result of the whole past existence and future purpose of the factory organization. Experience is expensive before it becomes a direct source of profit; equipment, working force, financial resources and goodwill all enter into the cost, not only of the factory product of to-day, but also of the product of future days and years. The cost of the day's product, therefore, includes more than the chance portion of the total cost of operating the plant that happens to get into the day's accounts.

Cost records are expensive, and, therefore, have no reason for existence if not practically useful. They should show the works management that the cost of product is within its proper standards. For this purpose, the items of material and direct labor are sufficient, and the burden figure of secondary importance. But the cost figures should also show the sales department the minimum selling prices which will cover the total of operating cost. Material, direct labor and factory burden furnish only part of the total which selling price must cover in order to insure continued profit.

The determination of this extra overhead necessary to maintain an average of profit is the great problem of factory accounting. The tools in continuous use must carry the expense of those which may be idle, and the busy years must earn the profit for the times of bad trade. The reservation of a surplus, to provide stability of dividends, is generally approved. In an unprofitable year, the unearned dividend may then be paid from the surplus. The use of an account for unearned burden, and offsetting this deficit by a proper increase in the general overhead rate, is exactly parallel. Every lost minute of operation causes a loss in earnings. If idle tools are necessary incidents of the business, the losses on them must be made up from the general income of the plant, or a deficit will result. This accords with the principle set forth by the author. The time lost in the factory operation must in the end be paid for by a mortgage on the busy hours; but there is no reason why the mortgage should be foreclosed immediately by writing off the whole cost of operation against the product of the lean month, when that would involve selling at an apparent loss.

It is indeed surprising that there are business men who do not seem to realize that high efficiency is more profitable than surplus capacity. As the charges on idle equipment must be carried by the equipment which runs, there should be just as little idle plant as possible. Fluctuations in demand are better cared for by increasing output with existing equipment, than by adding new tools which are likely to stand unused under average conditions. It is often easier to buy more machines than to find the causes of loss of output by the present ones. But, when the inevitable contraction comes, the management which has met demands by increasing the output of the existing plant instead of by adding equipment, is likely to be in position to continue dividends by drawing on an ample surplus.

Keppele Hall. The author's contention that overhead or indirect charges cannot be arbitrarily distributed over product without regard to conditions, and still have costs serve as a useful guide to the management or superintendent, is illustrated by the following example:

An electric light company in a small town was supplying current for lighting and a small amount of power. The business necessitated running the plant all day, although the day load was very light. An opportunity was offered to secure a very good day load by furnishing power to a street railway company, but the price at which the contract could be obtained was below the cost of production. This cost of production included the entire overhead expense prorated over the output. At first sight the proposition seemed undesirable; but on further investigation it appeared that, with the exception of a small amount of oil for lubrication and a negligible increase in depreciation owing to increased load, the only additional expenditure necessary to take on this business was the cost of the extra coal consumed and the removal of the extra ashes. No additional employees would be required in the power station or in the office. The contract was accepted and, in spite of the increased output, the price obtained was *below cost.* As a matter of fact the in-

come derived from this contract paid the company's entire coal bill and very handsomely increased the net profits. If this matter had been judged entirely on costs, it would have appeared a losing proposition, while as a matter of fact, it proved a dividend payer. Of course, this business could only be considered feasible as long as the demand for the higher priced lighting current did not encroach on the reserve capacity of the plant.

An objection that might be raised against the author's proposed solution of overhead expense distribution is that it does not hold the superintendent responsible for such items of the indirect expense as he has under his control during slack times. For example, suppose the normal output is 100 and necessary indirect expense is \$100. If the output drops to \$50 and the indirect expense to \$80, the output would be charged with \$50 and the remaining \$30 would be thrown into a profit and loss or business account. How are we to know whether or not the superintendent is rightly responsible for a portion of that \$30, which he might have saved? In such a case is it not advisable to divide the indirect expense, hold the product responsible for such portion of it as the superintendent can control, and relieve it of that portion over which he has no control?

It would appear that task work has a very important bearing on the subject of accurate costs. Where tasks have been scientifically set, and where the proper amount of material has been determined upon, the superintendent's chief responsibility is to see that, whatever the conditions of business, the work is done in the proper time and the proper amount of material is used. If this is strictly followed, any extra expense incurred on account of poor business conditions is not the superintendent's responsibility.

A good arrangement for proportioning indirect costs is to have a machine or work place rate fixed so as to cover all indirect expense under normal conditions. Each job is then charged with the direct labor and material and the machine or work place hours. The balance of the indirect expense, which is not absorbed by the machine and work place rates, is placed in an account known as an under-absorption account. This account increases in dull times and decreases in very busy times. The net result at the end of a given period shows the under or over-absorption of the indirect expense. The cost of the product is estimated from the sum of the three items (labor, material and machine or work place hours), and, except for variations in the efficiency with which the work is done, holds the costs practically constant. An account of this kind is very useful in equalizing costs over periods of slack production which are apt to occur in almost any business. It also serves to equalize unusual expenses which in some processes are incurred at certain periods of the year, such for example as with a product which requires a large amount of steam in cold weather and practically none in warm weather. This arrangement distributes this unusual expense over both periods and tends to equalize the cost.

A matter, which is not given the importance it deserves in management, is the fact that it is possible to regulate almost any business so there will be no great variation in output due to seasonal demands for the product or variations in the condition of business. Proper management should make an effort to control these conditions and has done so in a number of cases.

For example, a concern manufacturing automobiles has standardized its output so that it does not vary from one year's end to the other. This has been accomplished by offering special inducements to agents to dispose of the product during the dull season and also by manufacturing its product during this season, except some of the more expensive parts which can be put on in a comparatively short time, and holding this product until the seasonal demand arises.

Carl G. Barth. The question Mr. Gantt endeavors to answer in his paper is only another form of the old question of how low we may take orders in dull times, and it does not seem to me that he has reached the bottom of it.

The true answer to the question may be made no matter what the policy of a concern regarding the distribution of its overhead expenses, so long as these are definitely known and properly analysized.

This is by means of what Mr. Taylor called dull time "limit costs," the making up of which is practised by all concerns which fully understand the true nature of manufacturing costs.

In very dull times it is unfortunately not so much a question of how much money we can make by taking orders, but how to manage so as to hold an organization together and to lose as little money as possible, for the fixed charges go on even if we take no orders at all and allow the organization to disband.

In making up a "limit cost," we therefore leave out all consideration of the fixed charges of a plant, and also such other overhead expenses as, without being absolutely fixed, become so for the time being, because we purpose not to disrupt our organization entirely.

The overhead expenses to be added to flat labor and material in making up a limit cost are, therefore, such only as will actually be incurred by virtue of undertaking the work under consideration.

If this limit cost is less than the market value of an article it will then be correct to manufacture the article ourselves rather than to buy it, or to offer it in the market for anything, however little, over and above this limit cost, for this margin will help carry the fixed charges.

Suppose the limit cost of the article in the case cited in the paper could have been shown to figure up to 20 cents only, this would have constituted a still stronger argument against the buying of the article at 26 cents, even if the full and true cost at the time of manufacture was 30 cents.

R. E. Flanders. In the firm with which I am connected the plan is followed of setting the overhead rate to agree with average business conditions over a long period, taking into account both good times and bad. An overhead account is carried, to which are charged all the items that go to make up the shop overhead expense; and in like manner to this account are credited all sums apportioned as overhead charges to work in process.

In busy times there will evidently be a deficit in this overhead account. In dull times, on the contrary, the continuance of the heavy expenses, coupled with the small volume of productive labor to which they may be applied, will produce a heavy unapportioned balance in the account. The plan is so to set the average overhead rate that the deficits and excess balances will about cancel each other. From time to time this overhead rate requires adjustment to meet

changed business conditions, both internal and external. These changes are, however, neither frequent nor violent.

This plan, without doubt, is used by many other concerns besides my own, all of which have doubtless been led to adopt it for substantially the same reasons. It is worth while, therefore, to compare this plan, which we may call the *average rate* plan, with that set forth by the author, which we may call, for simplicity, the *proportional rate* plan.

In the first place, the average rate, being practically unchanging, is the more easily applied.

The average rate has the same advantage as the proportional rate in the matter of avoiding sudden and violent fluctuation in the cost figures due to corresponding fluctuation in the output.

The average rate offers the most direct method of distributing what may be called the "cataclysmic" overhead expenses. In this category are included such items as taxes, etc., which impose a disastrous load on the period in which they fall, unless they are apportioned piecemeal over the full term to which they apply.

The main difference between the two plans is that with the average rate the burden of carrying idle equipment and organization through dull times is distributed into the cost of work in good times, while the proportional rate takes it out of the cost system entirely and charges it to profit and loss.

Now, I contend that there is good reason for absorbing this periodically recurring expense in costs, rather than in profit and loss. This charge has not the nature of an extraneous calamity, like an embezzlement or unwise investment. We are forced, unfortunately, to reckon with cycles of boom and depression as one of the conditions of doing business in this country. This condition is therefore a regular factor in the cost of production, and should be so treated.

This argument becomes all the stronger when it is remembered that cost figures have a two-fold use. Not only are they employed for comparison with previous costs, but they are used as well to determine whether articles can be profitably manufactured at a given selling price; in some cases, in fact, they are used for setting selling prices. There is nothing like having all unavoidable expenses firmly imbedded in the cost figures, instead of allowing them to rattle around loose in the ledger.

To sum up the matter, it may be said that the use of the average rate directly disagrees with what the author states as a fallacy, that *all of the expense, however large, must be carried by the output produced, however small.* In fact, it seems to me to be the prime merit of the average rate plan, when based on an overhead account, that no legitimate expense escapes from distribution to costs. The errors which the author sees in this principle are not inherent in the principle at all, but are caused by an illogical application of it. The *average rate* seems to me to answer all, or nearly all, of his objections.

The proper solution of problems such as outlined by Mr. Gantt, of a factory running below normal capacity, is independent of any particular method of applying overhead charges. You can increase its output without perceptibly increasing the overhead charges, and you may safely reckon the cost of the increased production as equal to labor plus material only. Forget about the overhead. Any margin between the cost and the price at which you can buy or sell may be considered as profit, in the sense that it will, by that much, help to carry your overhead and thus reduce your expenses. This is not a matter of accounting, but of common sense.

In his discussion of the effect of the size of a plant and of a business the author opens up a line of thought which leads to interesting conclusions as to the ideal size of plant. That size, for a concern manufacturing staple articles, would seem to be such as to be able to take care of some reasonable percentage over the minimum demand in dull times. A plant so proportioned, with reserve and credit good enough to run full and build a fair stock in dull times, could be operated with the minimum attainable overhead rate. It would therefore capture practically all of this dull time business, and get, as well, the maximum profit on its output in good times, if it were well managed otherwise. In fact, the greatest danger to such a business would be the ever-present temptation to expand—a temptation which, if yielded to, might entirely undermine the foundations of its prosperity.

D. C. Ferner. Mr. Gantt's interesting paper suggests hope for a branch of cost accounting that is still struggling for intelligent analysis and even a semblance of uniformity. I refer to a proper determination of the cost of operating motor trucks. Every alternate step in production, conversion and distribution of any product is that of transportation. Raw stock, stock in process, finished stock must be moved on to the ultimate consumer. At many points motor driven road trucks, shop trucks, crane trucks, tractors and trailers can be used to advantage, but comparatively few managers can see the necessity for making the change. Present methods are built around equipment very limited as to capacity and sales value, but strong in associations, sentiment and book valuation. Depending on how good a horse trader the stable boss may be, the manager figures he can use horses and hand trucks for several years to come. He hesitates to adopt machine equipment on account of its initial cost, and its cost of operation. He has never kept accurate costs of horse delivery and the very limited amount of machine costs that are available are based on conditions that do not fit his business. He finds too that each machine is loaded with a fixed portion of the yearly overhead charges of the installation, whether the particular machine has been in operation all or a portion of the time. In other words a fixed charge is made against each machine working or idle and at the end of the year the total fixed charges for the year have figured prominently in the "cost of operation per mile" or per ton.

Following the author's suggestions, if a motor truck is laid up for lack of work its fixed charges or overhead for that period should be charged against profit and loss, and it should be up to the manager to find outside work for his trucks.

Going still further, if a motor truck is laid up for repairs, the fixed charges for that period of time should be added to the cost of repairs, and should not appear as fixed charges against the actual cost of operation.

By a proper analysis of operating and maintenance costs, the manager can always find a guide for reducing the idle time and increasing the earning capacity of each individual machine and the installation as a whole.

C. Bertrand Thompson. One important purpose of factory cost accounting is to provide a basis of comparison of

the cost of production from one period to another. Obviously, for this comparison to be of any value, the items to be compared must be based on similar conditions; or if this is impossible, the varying factor should be isolated in such a way that its influence may be separately considered.

A normal manufacturing cost is that which is accurate when the plant is running at its normal capacity, and this should be made the basis for comparison. Therefore, if the plant is not running at its normal capacity, the factor of idle time must be kept account of separately if comparisons are to be of any value.

The conclusion from these considerations is that in periods of depression and subnormal operation, costs should be figured on the basis of the equipment actually used, and the cost of idle equipment should be determined and charged simply in the profit and loss account, to be taken care of in the selling price so far as competitive conditions permit.

Mr. Gantt notes that this method may affect the policy of the plant, but unfortunately does not offer a suggestion as to what the new policy should be. Merely charging the cost of unused plant and equipment to profit and loss does not really solve the problem, which is—How can this loss be made good? When it is a question of closing whole plants there is a possibility of selling them and thus at least cutting off a part of the loss; but when it is a question of part of a plant being unused it is practically impossible to end the loss by merely disposing of the superfluous part.

One suggestion offered is to take the possibility of subnormal operation into account in setting the normal selling price. This is good so far as competition permits and so far as only average deviations from normal operations are anticipated. It cannot, however, take care of long continued abnormal conditions such as we have been experiencing. Viewed broadly, the condition of subnormal operation in a plant is due to the sales organization rather than the producing organization, not overlooking the fact that the sales organization has a perfectly legitimate excuse for not keeping the plant busy up to its fullest capacity. In view of this fact, the producing organization should not be penalized for the lack of opportunity to produce.

The excess cost should not of course be charged to the sales department any more than to the producing department. Special emphasis nevertheless, should be laid on the fact that it rests on the sales organization to reduce or eliminate the loss.

Here is a field for a further application of scientific management. Thus far this type of organization has been limited almost exclusively to production, and there it is doing extraordinarily effective work. Its successful practitioners in this field ought not to be expected to undertake the considerably different problem of distribution. But there is a clear call for the application to the marketing problem of the same type of analysis, scientific research and accurate determination of laws and principles that has characterized the development of scientific management in production.

William Kent. Mr. Gantt's paper is an admirable presentation of the evils that result from the adoption of a system of costkeeping, usually advocated by accountants, in which all the indirect expense, burden, or overhead, in a given period of time, such as a month, is charged as part of the cost of the output of that period, even if the amount of that output, on account of depression of business or other cause is far below normal. The only excuse for such a system is an accountant's one, that it enables the cost ledger to be balanced each month.

Mr. Gantt's statement of the general principle or theory of the correct method of charging indirect expense against product is strictly sound and logical, but it is not a new theory or principle. I have been acquainted with it and have believed in it for many years, although I do not recall that I have seen it in print. I have often made a statement of the principle something like this: " The burden to be charged against any product is the average burden of a normal year for the same quantity of product. If the total cost of keeping a certain machine in a shop for a year, including cost of light, heat, power, repairs, depreciation, rent, etc., divided by the number of hours the machine may be expected to run in a normal year is say 20 cents per machine hour, then the charge for burden to be made against the product of that machine is fixed at 20 cents per hour for the time the machine runs in the following year, whether it runs the normal number of hours or not."

In this connection attention may be called to an example of incorrect reasoning which sometimes follows a strict adherence to distributing burden on the machine hour system. An owner of a machine shop who had a tabulated hourly burden charge for each machine, varying with the size of the machine, the cost of running it and the number of hours that the machine was expected to run in a year, noticed that a small piece was being turned in a very large lathe. He told the foreman that he should not use the lathe for that piece because the burden charge on it was too heavy, and it would make the piece cost too much. The foreman replied that all the other lathes were busy and that there was no heavy work on hand for the large tool, and he thought he would make the big lathe " do something for its keep." The foreman was right, and, moreover, the burden that should be assessed against that piece in making up its cost, if the cost was to be used as a basis for estimating on future orders for similar pieces, is not the machine hour rate of the big lathe, but only that of a small one, on which the work would ordinarily be done.

The Author. If I am to draw any conclusions from the discussion of this paper, it has had the effect which I hoped it would have, namely, to make clear that a cost accountant to be really useful to a manufacturing company must understand the manufacturing process.

There is one point, however, which does not seem to have been clearly grasped by some, and that is that what I propose as the real cost of an article is not what it apparently has cost in the past, but what it should cost if the proper manufacturing methods were used and the shop were run at full capacity. This might be called the *ideal cost*, and toward its attainment all efforts should be directed. Mr. Polakov's discussion illustrates this most clearly.

It was perhaps twenty years ago when the great necessity for a knowledge of costs began to be apparent, and manufacturers in general began to give the subject careful consideration. The demand for " cost accountants " soon became so great that almost any clerk who had had experience in a manufactuirng plant was able to get a job as cost accountant, much as, today, almost anybody who calls himself an " efficiency engineer," even though he may never have had any

engineering experience whatever, seems to be able to gain the confidence of some manufacturer.

Such cost accountants, with a few high-sounding theories and a little bookkeeping experience, but with absolutely no shop knowledge, have too often been able to gain the confidence of the financier, whose policy has been governed by the reports obtained from such sources. The result of such an epidemic of cost accounting has undoubtedly been seriously detrimental to our industries, and it is with a great deal of satisfaction that I see the best accountants of today absolutely repudiating false theories and, if not actually keeping pace with engineers on the subject, at least traveling the same road.

The class of people that advertised themselves as "cost accountants" when "costs" was the watchword, today follow the slogan of "efficiency." This is certainly a step in advance as far as their work is concerned, but before we sacrifice everything on the altar of "efficiency," let us ask whether efficiency is a *means* or an *end,* and get the answer.

It is our duty to ourselves and to society to do well, or efficiently, whatever we do but are we not in danger of losing sight of our object if we lay too much stress on the efficiency with which we strive for it?

It does not take much thought to convince us that *efficiency* is not an *end,* but a *means;* and that it may be beneficial or detrimental as the end is worthy, or unworthy.

To do efficiently something that should not be done at all, benefits nobody. Would it not be better to do something worth while, however inefficiently? Let us stop, therefore, in this wild cry for efficiency long enough to ask what its proper aim is.

If its object is to enable the few to accumulate wealth at the expense of the many, it is not worth while, for an industrial system that allows this will finally fail. If its aim is to enable one man to take unfair advantage of another in any manner it is not suitable to a democratic nation; and it is the country as a whole that must be considered, when we discuss such a broad question as this.

The greatest problem before our industrial world today is the establishment of harmonious coöperative relations between employer and employee. Efficiency is one of the most potent factors in the solution of this great problem, but it can be directed either for or against this solution.

Should we not know on which side it is to be used before we commit ourselves to it?

Before we support too strongly, then, this striving for efficiency, let us be sure that it is to be directly toward a worthy object. Efficiency alone will not cure our troubles, for misdirected efficiency *may be* just as detrimental in the future, as misdirected *cost accounting* has been in the past.

On the other hand, a combination of properly directed efficiency and proper cost methods are absolutely essential to the solution of our industrial problems; and the hopeful thing about the newer ideas of cost keeping is that they point the way of measuring not only the efficiency of the workmen, but that of the manager and of the financier.

Past methods have too often not only failed in this respect, but have frequently been so devised as to relieve the man at the top of the responsibility that was justly his, and to saddle it on the subordinate. The introduction of methods that will relieve this situation will be a long step in the solution of our industrial problems.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

There are still some people inclined to make a distinction between theory and practice. An article abstracted in the present issue brings a rather striking illustration of the fact that of late such a distinction is rapidly losing its sense. On the face of it, an investigation into the velocity of reaction in chemical processes belonging to what is known as physical chemistry, would appear to be "highly theoretical" and quite removed from "practice" and yet here we have a description of an entirely practicable and apparently valuable process for the production of hydrogen, based exclusively on the knowledge of facts derived from an investigation into the velocities of reaction at various temperatures as affecting the relative inertia of chemical processes.

### THIS MONTH'S ARTICLES

The analysis and testing of explosion engine fuels are extensively discussed in an article in a German periodical.

Data of tests on air permeability of various building materials are reported, including such comparatively recent materials as chalky sandstone and perforated bricks.

The theory of resistance of rolling a hard body over a plastic surface is reported from an article in a Russian technical periodical, where also are given data from tests on the power consumed by wheels equipped with metal tires rolling over soft ground, of the power consumption in pure rolling of an American caterpillar tractor and the economy obtained in transporting heavy pieces of artillery by the use of the so-called Bonagente band.

An automatically operating refrigerating apparatus of Swiss design is described in considerable detail.

In the section on Steam Engineering is described a special system of replacing boiler tubes, which not only allows of the use of old tubes over and over again, but makes a joint between an old tube and the boiler actually stronger than one between the boiler and a new tube to which this method has not been applied. In the same section are discussed methods of calculation of safety valves with high lifts. The author shows that the so-called Cario formula for safety valves with high lift does not apply in the case of high efficiency boilers, and quotes tests showing that with valves dimensioned in accordance with that formula, the steam pressure may, under certain conditions, exceed the maximum permitted limit. A process of calculating de Laval nozzles by means of the PV diagram is reported from a German periodical.

From the Journal of the American Society of Naval Engineers is abstracted a paper on heat transmission and tube length in marine feed water heaters, by Leo Loeb. Particular attention is called to this paper both on account of the experimental data reported and very interesting theoretical considerations presented by the author.

Some fallacies in cement testing are discussed by W. Lawrence Gadd in the Transactions of the Concrete Institute. Among other things, the author calls attention to the fact that tests of fineness of cement are apt to give erratic results because the mesh of the sieve is but seldom uniform and also because, while the mesh is specified, the size of the sieve which may materially affect the results is, as a rule (in particular in the British Standard specifications), overlooked. The author likewise does not see that there is any use in the specific gravity test.

A paper by F. J. Schlink, on automatic scales, has been abstracted from an advance publication in the Scale Journal. It is of interest as giving a reliable classification of various types of automatic scales and describes the various fundamental principles of their construction.

The very important subject of the hardening of metals is discussed in abstract from the Transactions of the Faraday Society. While lack of space prevented the giving of more detailed abstract of the various papers presented to the Society on that subject, it is believed that interesting data will be found in the abstract of papers by Professor Ernst Cohen, of Utrecht, J. C. W. Humfrey (The Amorphous Phase in the Hardening of Steels) and Sir Robert Hadfield.

The question of the future developments in heating and ventilating is discussed by A. H. Barker, before the Society of Engineers. The author takes a rather novel view of some sides of that important branch of engineering, reports data of interesting tests and, among other things, explains certain phenomena which have been recognized for a long time but not fully understood; e.g., the unpleasant effect produced by radiator heat. The author distinguishes between temperature of air and radiant temperature, describes apparatus for measuring either of the two and attempts to throw light on some little understood phenomena by separating both the above referred to kinds of temperature.

From a bulletin of the University of Illinois are described experiments referring to the study of boiler losses.

## FOREIGN REVIEW

### Internal-Combustion Engineering

Analysis and Testing of Explosion Engine Fuels.

The article discusses the question of the utilization of gasoline, benzol, motor spirit and other fuels in explosion engines, with special regard to automobile motors. It is very complete, covers extensive references to German publications, both books and articles, and goes fully into the question of analysis and testing.

The author points out that hitherto the sale of gasoline, benzol, etc., was mainly based on confidence in the seller and that it is only quite recently that an attempt at establishing specifications has been made. The author believes that the pleasure vehicle will use, in the future as now, real gasoline, which he calls, in this connection, "luxury" gasoline; that the commercial vehicle might use mixtures of gasoline and benzol or heavier oil generally, and that stationary engines will use the cheapest and heaviest grades.

As mentioned above, the author discusses in detail the methods of testing motor fuels, under the following heads: *a* Determination of specific weight; *b* Color and external appearance; *c* Test by smell of the filter residue; *d* Length of evaporation on a watch glass; *e* Behavior with respect to litmus paper; *f* Color reaction with sulphuric acid; *g* Qualitative and quantitative determination of aromatic hydrocarbons and unsaturated combinations; *h* Benzol test by

means of isatin and sulphuric acid, (0.1 isatin and 30 grams sulphuric acid); *i* Benzol test by nitration with nitric and sulphuric acids; *j* Benzol test by means of "dragon ruby" (a special preparation made from pitch obtained from the blood of a Sumatra palm dragon); *k* Test for the determination of coal tar, lignite, benzine and sulphur compounds by means of silver nitrate; *l* Test for water by means of calcium chloride; *m* Fractional distillation; and, *n* Investigation of fuels by refraction.

The purpose of the article is to help in establishing a standard specification for fuels used for various purposes; the author gives samples of such specifications, viz., three specifications for gasoline (light automobile grade, middle weight commercial vehicle grade, and the still heavier grade for stationary engines) motor benzol and motor spirit. *Die Analyse und Wertbestimmung der Motoren-Benzine, -Benzole und des Motor-Spiritus des Handels*, Dr. Karl Dieterich, *Automobil-Rundschau*, vol. 16, no. 9/10, p. 65, May 1915, 32 pp., *peA*.

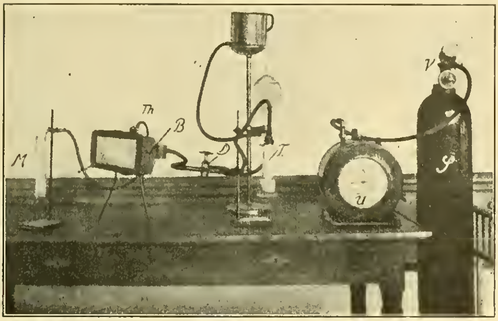


Fig. 1A Arrangement for Testing Air Permeability of Building Materials

Running Diesel Engines on Tar Oils.

By cutting off the supplies of Galician oils, the war forced the Austrian engineers to turn their attention to other sources of fuel for running Diesel engines. The most natural were various forms of tars and tar oils with which considerable experience has been gained elsewhere previous to the war. The present article discusses the character of these new fuels, their methods of use (with some practical advices), and design of Diesel engines for heavy oils. Some test data are given. (*Dieselmotoren mit Teerölbetrieb*, Hans Schmidt, *Elektrotechnik und Maschinenbau*, vol. 33, no. 23, p. 277, June 6, 1915, 6 pp., *p*).

## Materials of Construction

Air Permeability of Building Materials.

This paper presents data on air permeability of various building materials.

Investigations on the same subject have been previously carried out by C. Lang (in 1877) and by W. Gosebruch (in 1897). The present investigation was carried out in the laboratory of technical physics of the Technical High School at Munich, and was prompted by the necessity of determining the air permeability of materials which have been brought out on the market in recent years, for example, chalky sandstones.

The permeability was determined by means of the experimental arrangement shown in Fig. 1A. The stone *St* was placed in a funnel shaped sheet iron container *B* and packed, air tight, on the sides with a mixture of plastilin and putty made of wax and colophonium. The stone, on one side, is exposed to atmospheric air and on the other side to a gage pressure of about 100 mm of water produced by an air supply from the steel flask *S* containing air under a pressure of 150 atmospheres and equipped with the reducing valve *V*, by means of which the air can be taken for any length of time at any pressure desired. From the valve, the air passes through an air meter *U* and a drying flask *T*, to the funnel *B*. The drying flask contains calcium chloride by means of which the moisture is, as far as possible, kept away from the stone *St*. Between *T* and *B* there is a three-way cock *D*, by means of which the air meter *U* may be calibrated without dismantling the experimental arrangement (the method of calibration of the meter is described in detail). Directly in front of the material investigated are located, through cock

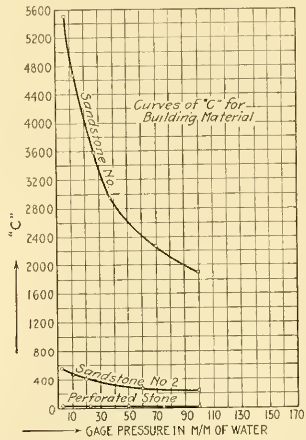


Fig. 1B Curves Showing Coefficient of Permeability for Building Materials

stoppers, a water manometer *M* and thermometer *Th*. The readings of these instruments enable one to reduce the volume of air flowing through to the normal conditions of 760 mm mercury pressure and 0 deg. cent. temperature.

The material investigated was of various thicknesses, on the average 60 mm. The part of the stone facing the outside atmosphere had often to be limited to 10 x 10 cm. because with a larger area of outflow the air velocities in the meter and drying flask were too high, which created undesirable disturbances, such as carrying over of particles of calcium chloride into the piping. The duration of test was, on the average, 30 min., and air temperature about 20 deg. cent.

Each test was, as a rule, repeated three times and the data reported represent an average of all the three tests. The Lang law was sometimes used in calculations; viz., that the volume of air flowing through is inversely proportional to the thickness of the material. The values obtained are shown in the second column of Table 1. From them is calculated

the coefficient of permeability $c$, under the assumption that the volume of air $Q$ flowing in a unit of time through an area $F$ of stone is inversely proportional to its thickness $d$, and directly proportional to the gage pressure $p$. Under this assumption the volume of air flowing through the stone is defined by the equation

$$Q = c\, p.\, F$$

and $c$ indicates therefore the volume which will flow per hour through 1 sq. m. of stone surface, 1 m. thick, at a gage pressure of 1 mm. of water (Table 1, because of lack of space, is given in an abbreviated form). The "perforated stones" were bricks having four cylindrical perforations of 4 cm. in diameter, running parallel to their long edge, 12 cm. long. In addition to tests at the constant gage pressure of 100 mm, a series of tests were also made at variable pressures, data of which are given in the original article in

TABLE 1 DATA OF TESTS ON AIR PERMEABILITY OF BUILDING MATERIALS

| Material | Q — 1 per hr. | c (Average value) |
|---|---|---|
| Sandstone | 5,680,000 | |
| | 3,715,500 | |
| | 3,136,500 | 997 |
| Chalky sandstone | 76,060 | |
| | 39,170 | |
| | 29,060 | 14.4 |
| | 4,890 | |
| | 4,760 | |
| | 2,670 | 1.23 |
| Perforated brick | 36,640 | |
| | 32,720 | |
| | 7,474 | |
| | 4,547 | 5.83 |
| Hand made brick (hard burned) | 7,540 | 2.26 |
| Machine made brick | 8,346 | |
| | 6,820 | |
| | 1,915 | |
| | 1,880 | 1.42 |

a table. From these data, the coefficient of air permeability $c$ was calculated and is shown in the curves of Fig. B. As has already been noticed by Gosebruch, $c$ is not constant but increases as the pressure decreases, this increase being materially greater with goods of porous material than with tougher materials. The decrease of air permeability with an increase of the pressure differences is to be e plained by the fact that the rapid growth of frictional resistance at greater pressure differences, and hence increased velocity of flow, produces a strong reduction of the motion of air through the material in the case of materials with very large pores. There is, in addition to that, the influence of flow produced by the phenomenon of expansion and turbulent motion in the hollows which affects still more the air permeability of the material at higher pressures. (*Die Luftdurchlässigkeit von Baumaterialien,* Hans Freiherr von Thielmann, *Gesundheits-Ingenieur,* vol. 38, no. 23, p. 265, June 5, 1915, 3pp., 3 figs. *e.*)

### Mechanics

THEORY OF RESISTANCE TO ROLLING OF A HARD BODY OVER A PLASTIC SURFACE

The present investigation has been made in connection with the design of the first tractor constructed in Russia.

When the tractor was first built, it was found that losses due to pure rolling constituted 40 per cent of the useful output of the engine, which of course made the tractor very inefficient. Certain alterations of design reduced these losses to 25 per cent., which showed the importance of accurately understanding the phenomenon of rolling resistance. The present investigation has in view only rolling resistance of such bodies as wheels of wagons, tractors, and chains used on caterpillar tractors. In addition to that are investigated the driven wheels of modern heavy field artillery pieces, equipped with flat band shoes of the Bonagente type.

The general property of the surface of rolling of such bodies is that one can entirely neglect both the elastic and permanent deformation in their surfaces of rolling as compared with the deformation of the roadways of rolling (such as have been considered in the present case). These limitations exclude the use of rubber automobile tires and other elastic tires. Further, the investigation is limited to the case of rolling where the resistance to rolling is sufficiently large; that means types of ground, and such loads, which permit of neglecting the elastic deformation of the roadway as compared with its permanent deformation.

Finally, in order to derive general laws of rolling resistance, it is necessary to know the law of resistance of the ground to crushing under the conditions of crushing which occur in rolling. The author derives the following formula for expressing the specific resistance $f$ in kg per sq. cm of the ground to crushing

$$f = f_o . y \ldots\ldots\ldots\ldots [1]$$

where $f_o$ (In kg per cu. cm) is the coefficient of specific resistance of the ground to crushing, i. e., the load in kg per 1 sq. cm of surface of ground, which causes permanent deformation of the ground to a depth of 1 cm. This formula shows that the specific resistance of the ground to crushing is proportional to the depth of the permanent deformation or crushing which corresponds to it.

As regards the resistance to rolling proper, *Appell* considers that pure resistance to rolling represents a couple opposing the rolling; the axis of this couple is parallel to the line of contact between the rolling body and ground, and may be located along the latter. The author considers only the case when the rolling body moves uniformly forward along a horizontal surface. The resistance to rolling $R$, he measures by the work of rolling $L_k$ referred to a unit of length of path $l$ travelled through by the body. In such a definition, the resistance to rolling is thought of as a certain imaginary force applied at all points of the rolling body, which has its axis of rotation traveling through paths identical with that of the entire body. The work of rolling in the general case is that work of the rolling body which is done by the surface forces acting between the surfaces of the rolling body and the ground (while the work of rolling necessarily includes that of sliding, the latter is here neglected). If the rolling body is assumed to be hard, no work is spent on the deformation of its surface since none is supposed to take place. In the case of rolling a hard body over plastic ground, the entire work of rolling represents the work of crushing of the ground, its slip and friction of the surface of rolling against the ground. The work of internal resistance, such as friction in the journals, and the work of gravity on inclines, are not included in the work of rolling. The essential feature in the dynamic method applied by the author to the determination of resistance to rolling is the

calculation of the work of deformation of the ground, the latter being determined from the conditions of equilibrium of the body, i. e., equilibrium of load applied to it, tractive effort and resistances of the ground.

From this, the author proceeds to the investigation of resistance to rolling on soft ground of the endless chain of a caterpillar (the tests were made on an American tractor made by the Holt Caterpillar Tractor Company). In the first part of the investigation it is assumed that the chain is smooth; that is, without protuberances which grip against the ground. The width of the chain is $B$ cm and the length, $L$ cm. The load $Q$ kg is assumed to be distributed uniformly over all of the bearing surface, the specific pressure of this surface against the ground being represented by $q = \frac{Q}{BL}$. In that case, in the ground a deformation will occur to the depth $y_o$, at which the specific resistance of the ground $f$ in kg per sq. cm will balance the specific resistance of the bearing surface $q = f$, wherein $f = f_o.y_o$.

It was found, by the way, that if the average value of $f_o$ of specific resistance of the ground be known, the depth of crushing of ground by the caterpillar of the tractor can be found from the following expressions:

$$y_o = \frac{Q}{f_o\,B.L}\,;\; f_o = \frac{Q}{y_o\,B.L}\;;\; Q = f_o.y_o.\,B.L \ldots\ldots\ldots [2]$$

In order to calculate the work of compression of the ground to the depth $y_o$ cm, the coefficient $f_o$ is assumed to be the same as above, which means that the work of slip of ground and the work of gliding of the chain over the ground is neglected, which can be done because these losses are actually practically negligible. The specific resistance of the ground $f$, which is overcome over an elementary section of the ground $dy$, will cause an expenditure of work $f.dy$ and over the whole path $y_o$ the compression of the ground $l_o = \int_o^y F\,.\,dy = \int_o^y F_o\,.\,y_o\,dy = F_o\,\frac{y_o^2}{2}$ which is (in kg per cm) the *specific work of deformation*, on the assumption that the specific pressures and depths of deformation are proportional to each other. Let the specific resistance of the chain to rolling be equal to $R$ kg, and the tractor travel an arbitrary distance of $s$ cm. The work done by the resistance $R$ will then be $Rs$ kg per cm and this work of rolling is the work of deformation of the ground. But if the tractor travel through a distance $s$ cm, the deformation made by the chain over this distance will represent a groove of area $Bs$ and depth $y_o$ cm. The specific work of deformation to depth $y_o$ is $F_o\frac{y_o^2}{2}$ and hence the total work of deformation over an area $Bs$ will be

$$Bs\,F_o\,\frac{y_o^2}{2} = Rs, \text{ hence}$$

$$R = \frac{F_o\,y_o^2}{2}\;.\;B \ldots\ldots\ldots\ldots\ldots\ldots [3]$$

From this the author proceeds to the investigation of resistance to rolling of wheels of heavy artillery pieces equipped with flat band shoes of the Bonagente type. He goes through the calculation very carefully, and, among other things, compares the resistance to rolling of a Bonagente band with resistance to rolling of a cylindrical wheel of the same diameter and width of rim. He determines the formula and finds that while, with the Bonagente band, the expenditure of energy for the motion of the heavier gun is 3.14 h.p., the same gun, when moved on wide cylindrical wheels, will require 19.3 effective h.p., which shows that the introduction of flat movable supporting elements on the surface of rolling axles of all kinds of conveyances decreases the resistance to rolling of this surface many times. Among other things, he shows that in a chain (caterpillar type) rolling along a certain roadway, the coefficient of resistance to rolling increases in proportion to the load, while the resistance to rolling of the chain increases in proportion to the square of the load; hence, it is very inadvisable to overload the chain. With the same specific load per unit of over-all supporting surface of the chain, the resistance to rolling and the coefficient of the resistance to rolling of the body is greater the wider the chain and smaller the narrower the chain, but a long narrow chain is more advantageous than a wide, short one. In this connection, the author points out an interesting similarity between the caterpillar chain on one hand and a ski or skate on the other hand. Experience has shown that the latter two must be long and narrow in order to reduce the resistance to minimum. In general, whenever the friction of gliding goes together with crushing, destruction, or wearing of the roadway, it will depend not only on specific pressure of the body against the roadway, but also on the width of the body normal to the direction of motion. (*Teoriya soprotivlenya katanya tverdava tyela po plasticheskamoo pooti*, B. B. Schultz, *Proceedings of the Imperial Russian Technical Society* (in Russian), vol. 49, no. 3, p. 81, March 1915, article not finished. *etA*).

## Refrigeration

### Automatically Operating Refrigerating Apparatus "Autofrigor"

The article describes refrigerating devices and installations of the Swiss Federal Exposition in Bern 1914. The part abstracted here refers to an automatic cooling apparatus for household use, called "Autofrigor," built by Esher Wyss & Co., Zurich, Switzerland.

The apparatus consists essentially of a reciprocating compressor built in, together with the condenser, in the casing $K$ and driven by a vertical shaft from the electric motor $M$. Below the casing is located a ribbed evaporator $R$, the whole having therefore the shape of a vertical cylinder and taking up very little room. Methyl chloride is used as a cooling medium. Many of the details of design are of interest. The cylinder of the compressor $z$, has an oscillating motion. It is supported by transversal pins and presses upward by a spring against the slide face provided with suction slots forming the path by which the gas penetrates from the suction chamber $a$ into the double acting cylinder, and then, by the pressure valve $v$, into the lower pressure space $b$. The ascending pipe $r_1$ conducts the gas to the upper pressure chamber $c$ and pipe $r_2$ to the condenser $e$. The latter has an annular shape and is equipped with ribs running screw-wise, this being done in order to force the cooling medium to describe a longer path. The liquid which condenses because of the inclined position of the ribs, sticks in the neighborhood of the cold outer wall. The condenser is surrounded by a jacket $m$, through which cooling water flows in countercurrent. This external annular chamber is also provided with ribs in order to increase the water velocity. When it is necessary to clean the cooling surfaces, the jacket $m$ can be easily taken off without opening the engine itself.

The cooling liquid condensing in the condenser collects at the bottom of the chamber *e* and then flows through the reducing nozzle *d*, where the pressure and temperature are reduced to the lowest stage possible in the evaporator. Instead of the regulating valve necessary with the ordinary ice machine, here an expansion nozzle is used. The evaporator *R*, provided with ribs, takes up heat from outside and is protected by a sheet iron jacket in order to prevent the cooling liquid near the walls from being affected by the heat of the evaporator.

The construction of the driving motor *M* is also peculiar.

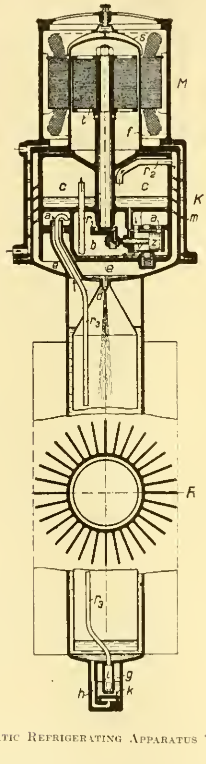


Fig. 2 Automatic Refrigerating Apparatus "Autofrigor"

Its rotor *t* is enclosed by a rigidly fixed armature and separated from it by a steel liner *f*. In order to have the eddy loss low, this liner is made of a special steel. In this way the pressure chambers *b* and *c* are separated from the outside atmosphere, air tight, without the use of any stuffing box. *f* has therefore to stand the gas pressure at the upper temperature stage which, in accordance with the temperature of the cooling water, may vary from 1.6 to 6 atmospheres. Tests made with this liner have, however, shown that permanent deformation occurs only at pressures from 80 to 100 atmospheres.

The lubrication of all movable parts has been provided for with particular care. Glycerine, which is used for this purpose, is placed in the upper pressure chamber *c*, and from there reaches all the lubricated parts of the compressor,—the piston, crank and shaft ends. It then collects in the lower pressure chamber *b*, and is carried over again into the chamber *c* by the cooling medium, through the pipe $r_1$. The pipes $r_1$ and $r_2$ open therefore into the chamber *c* in such a manner that the lubricant would never, not even with the apparatus in a horizontal position, overflow and run from the apparatus. A small part of the glycerine is atomized and carried off by the cooling medium to the condenser chamber *e* and by nozzle *d* penetrates into the evaporator *R* where it collects at the bottom. When the machine is stopped, the pressure between *c*, *e* and *R* rapidly equalizes through the open nozzle *d*, while the small evaporator pressure in the container *g* under *R* is still maintained. There, however, the lubricant meets with the cooling medium, and is forced into the container *g* through the hole *h* and isolating valve *k*.

The article describes further a carbon dioxide compressor and an ammonia compressor; also a double acting compressor for sulphurous acid and the Audiffren-Singrün refrigerating machine. (*Die Kälte-Anlagen an der Schweiz. Landesausstellung Bern 1914,* Professor P. Ostertag, *Schweizerische Bauzeitung,* vol. 65, no. 26, p. 289, June 26, 1915, 4 pp., 10 figs., *d*).

**Steam Engineering**

Pikal System of Boiler Tube Replacement.

The article describes the so-called Pikal method of tube beading used both in fire tube and water tube boilers. It is well known that whenever a tube in a boiler has to be replaced a new tube must be used, as the processes now in use do not admit of securely welding on an old tube. Further, all processes of welding-in tubes have the added disadvantage of reducing the inner diameter of the tubing, because of the overlapping at the place of welding. The Pikal method is claimed to permit of the use of old tubes without that disadvantage because as shown in Fig. 3, the use of a soft iron beading insert permits not only of the use of the old tubes but of their improvement in such a manner that they become even better than ordinary new tubes without the soft iron beading insert.

The main value of the use of the reinforced soft iron beading element lies in the fact that it is made of soft material, contrary to the usual practice, softer than the walls of the boiler tube. As a matter of fact, when hard boiler tubing is beaded into the tube wall, and the tube has a higher strength than the tube wall (50 kg. per sq.m. as against 40 kg.), the limits of expansion of the two materials are in the same ratio. As a result, the limit of elongation of the tube wall is reached earlier than that of the tube itself. Iron which has reached its limit of elongation through continued expansion is no longer elastic and tends to maintain its expanded dimensions; hence the extended bore of the tube wall retains its expansion (compare 2 in Fig. O), while the tube which is still elastic does come back to its original diameter. As a result, the tube and tube wall bore get out of touch and the tube does not sit steam-tight in the bore. A further beading is therefore necessary until the tube reaches *its* limit of expansion and in the end one has a contact between two materials, both of which are stressed beyond their limit of elasticity; which is neither permanent nor reliable.

In the Pikal process an entirely different situation is said to exist. The beading insert (tube) has a lower strength than the tube wall and therefore is the first to exceed its limit of elasticity. As a result, the tube wall even after a

comparatively long beading does not reach it at all if the process has been applied properly, and therefore remains elastic and encloses the no longer elastic end of the tube, thus creating a steam-tight and permanent contact.

Tests on the permanence of the Pikal method of locating the tube ends in the tube wall have been made at the laboratory of technical mechanics, at the Technical High School in Vienna and are said to have shown that the Pikal tube end sits tighter in the tube wall than an ordinary boiler tube. The tension in which the test piece came out from the tube wall was, with ordinary fire or water tubes, on the average 6310 kg. (13882 lb.) and with the Pikal attachments, 8320 kg. (18204 lb.). The Pikal process is especially applicable to old boilers. (*Das Pikalsche Rohrwechsel-Verfahren und seine praktische Anwendung, Der praktische Maschinen-Konstrukteur*, vol. 48, no. 23/24, p. 105 (General Section), June 17, 1915, 3 pp., 2 figs. *de*).

### Calculation of Dimensions of Safety Valves with High Lift.

Discussion of methods of calculation of safety valves with high lifts. Criticism of the Cario formula and experimental proof that this formula does not give sufficiently large values in the case of high efficiency boilers.

According to German police regulations for land boilers (Section 2, paragraph 9, December 17, 1908)—"Safety valves must carry such maximum load that when the pressure stipulated for a given boiler has been reached, all steam in excess of that should be able to escape. The cross-section of the safety valves must, under normal conditions of operation, be such as to be able to allow of the escape of enough steam so that the stipulated pressure should not be exceeded by more than one tenth its amount." According to the same regulations, the cross-section of the safety valves is sufficient if determined by the following formula:

$$F = 15\,H \sqrt{\frac{1000}{p\,\gamma}}$$

where $F$ is the cross-section of the valve in sq. mm $H$ the heating area of the boiler in square meters $p$ the gage pressure of steam in kg. per sq. cm.; $\gamma$ the weight of 1 cbm. of steam at gage pressure $p$ in kg. In the case of a high lift valve of which the lift is at least $= \frac{d}{4}$ (where $d$ is the diameter of the valve), instead of the coefficient 15 in the above formula, a coefficient 5 may be used, but in this case the manufacturer of the valve must guarantee that the lift indicated will be available in the case of a pressure e ceeding a stipulated steam pressure by one tenth. The above formula is derived from the general formula

$$F = d\,h = \frac{D}{5} \cdot \frac{1}{\mu} \sqrt{\frac{1}{p \cdot \gamma}}$$

where $h$ is the lift of the valve in mm; $D$ the amount in kg. of steam generated per square meter of heating surface per hour; $\mu$ coefficient of outflow of steam. The disadvantage of the above formula is that it does not seem to take into consideration the rate of output of steam in the boiler. It does not appear reasonable to provide safety valves of the same dimensions on the combined fire tube-smoke tube boiler, and the high efficiency boiler having an output of steam three or four times per unit of heating surface as large as the former. As a matter of fact the following case shows that when the load on the heating surface of the boiler is more than 30 kg. per sq. m. per hour, high lift safety valves calculated in accordance with the above formula do not afford sufficient protection against excessive overloads.

In the power plant of the Rhine-Westphalian Electric Co. there was installed a high efficiency boiler having a heating area of 973 sq. m. and a grate area of 36.8 sq. m. It was provided with four high lift safety valves of 70 mm diameter, each sufficient to take care of excessive pressures in accordance with the above quoted police regulations. For experimental purposes, the steam outflow on the boiler was suddenly closed by an automatically operated rapid closing valve so that the entire amount of steam generated had to be let out by the safety valves. Although the latter were going full blast, the steam pressure rose to 17 atmospheres (safety limit 15.4 atmospheres) and would probably have gone up still further had not the fire been put out. In this case, therefore, even though the safety valves had been dimensioned in accordance with the police requirements, they could not prevent an excessive rise of pressure, and instead of four, six such valves had to be installed. While as a matter of fact such a situation as was experimentally allowed to take place here, would not usually be met with under ordinary conditions, as it would be only under very exceptional

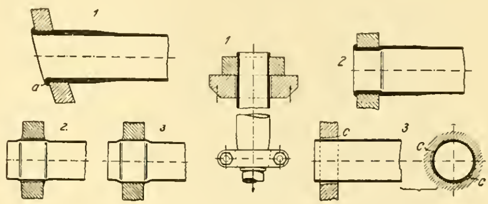

Fig. 3 Pikal System of Boiler Tube Replacement

circumstances that the entire output of steam would be cut off and the valves would have to take care of the steam generated, still it shows that safety valves dimensioned in accordance with the above formula are not sufficient to take care of the output in any high efficiency boilers. The author proposes, therefore, instead of the above formula, the following two formulae:

$$F_n = \frac{Q_{max}}{2} \sqrt{\frac{1000}{p \cdot \gamma}} \text{ for ordinary safety valves}$$

$$F_h = \frac{Q_{max}}{6} \sqrt{\frac{1000}{p \cdot \gamma}} \text{ for safety valves with high lift}$$

where $Q_{max}$ is the maximum steam output of the boiler per hour (in kg.). In this formula the heating area of the boiler is not taken into account at all, which is reasonable because it has no uniform influence on the amount of steam generated. (*Beitrag zur Berechnung von Hochhub-Sicherheitsventilen*, Otte, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 38, no. 22, p. 183, May 28, 1915, 2 pp. *tpe*.)

### Calculation of the Laval Nozzle by the PV Diagram.

The adiabatic variation of state is given by the equation:

$$PV^k = \text{Const.} \quad [1]$$

If we denote

$$\lambda = \frac{k}{k-1} PV \quad [2]$$

it follows that

$$\lambda\, V^{k-1} = \text{Constant} \quad [3]$$

$\lambda$ is really the heat content of the medium at the state $P$, $V$.

The constant which is missing on the right side, can be neglected since, as we are going to show later, it is not the absolute values of $\lambda$, but the difference between these values that is of determining importance.

In Fig. 4 is plotted the curve $PV^k$ = Const.; for saturated steam $k = 1.135$, for an initial pressure of 10 atmospheres absolute. To do this, the Brauer method was used, with $\tan \alpha = 0.2$, and $\tan \beta = 0.23$. The curve determined from equation [3] can also be plotted by the Brauer method with a slight alteration necessary for conveniently plotting the curve. The alteration consists in that, instead of 45 deg.,

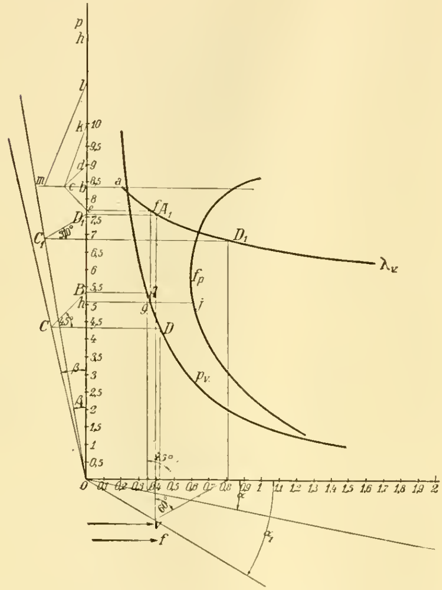


FIG. 4 DIAGRAM SHOWING METHOD OF CALCULATION OF LAVAL NOZZLES

for the axis of ordinates 30 deg., and for the axis of abscissae 60 deg. are taken, whence the equation

$$1 + \tan 30^\circ \tan \beta_1 = (1 + \tan 60^\circ \tan \alpha_1)^{k-1} \ldots [4]$$

is obtained. If we select $\beta_1 = 10$ deg., then $\alpha_1 = 31$ deg.

In this way the curve $\lambda\ V$ can be rapidly plotted (a further simplification may be introduced, by making $\beta = \beta_1$, or $\alpha = \alpha_1$).

The steam and gas velocity is determined from

$$c = \alpha \sqrt{\lambda_2 - \lambda_1} \ldots\ldots\ldots\ldots\ldots [5]$$

The cross-section of the nozzle

$$\frac{c}{V} = \frac{1}{f} \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

From $f$ the cross-section can be easily determined, and e. g. for a circular orifice

$$d = \beta \sqrt{f} \ldots\ldots\ldots\ldots\ldots [7]$$

The calculations of [5], [6] and [7] can be very easily carried out graphically. If we select on the axis of ordinates a point $b$ corresponding to the origin of the $\lambda\ V$ curve, and then select on the same axis a second point $d$, and, starting from $d$, draw rectangular triangles of which the apexes of the right angles lie on the straight line $ab$, then it follows (Fig. 4) that

$$\frac{e\ b}{e_1\ b_1} = \sqrt{\frac{c\ b}{c_1\ b_1}} \text{ or } \sqrt{\frac{\lambda}{\lambda_1}} = \frac{c}{c_1}$$

that is, the velocities can be measured off on the line $ab$. If now the specific volumes $\overline{ef}$ corresponding to these points be plotted from $b$ upwards on the axis of ordinates, a point $m$ selected on the line $ab$, and from $m$ a line equal to $ml$ be drawn parallel to $ck$, then $bl = hj$ is the required cross-section. In this way can be determined the single points, and the curve $fp$ plotted.

To determine the scale, values must be calculated for some definite point or state. The points $d$ and $m$ should be selected so that no sharp intersections of the lines should occur: a little practice will enable one to do this easily. (*Berechnung einer Lavalschen Düse mit Hilfe der pv-Diagramme*, Arthur Balog, *Zeits. für das gesamte Turbinenwesen*, vol. 12, no. 16, p. 181, June 10, 1915, 2 pp., 1 fig. *mp.*)

**Varia**

NEW METHOD OF PRODUCING PURE COMPRESSED HYDROGEN.

Until recently, hydrogen was a by-product of secondary importance, mainly burned in various ways. Of late, however, several chemical processes, such as the production of synthetic ammonia, and the use of hydrogen in autogenous welding, have created a big demand for it, by no means satisfied by the existing methods of production. The present method utilizes the decomposition of water under pressure, by iron.

Experiments in physical chemistry have shown that some elements, apparently inert, enter into various reactions under different conditions of temperature and pressure, and that the apparent inertness is really due to the low velocity of reaction, so that by changing the conditions of reaction, it becomes possible, for example, to unite apparently inert nitrogen with various elements, to introduce by means of catalysis hydrogen into unsaturated organic combinations, and finally to unite these two inert gases into synthetic ammonia. Coming more nearly to the production of hydrogen, in existing processes steam is decomposed by acting on hot iron. If, however, the reaction occurs at a low temperature, it becomes too slow. The effort of the inventor in the present instance has been to obtain the decomposition of water at as low a temperature as possible, so as to avoid contamination of hydrogen by carbon monoxide, which would make it useless for certain chemical processes; at the same time it was desired to carry on the reaction at a high speed so as to make its commercial application possible. To do this, water could not be used in the form of steam because, under 400 deg. cent., the velocity of reaction of steam with either carbon or metals is too low. Hence a new principle was applied and water was decomposed whilst in a liquid state at temperatures lying between its boiling point and 400 deg. cent. As the decomposition was carried on by means of carbon, what was practically obtained was burning carbon under flowing water. The reaction occurred in accordance with the formula

$$C + 2\ H_2O = CO_2 + 2H_2$$

which shows that hydrogen and carbon dioxide were obtained in the correct stoichiometric ratio. In its simplest form, the reaction, however, goes on very slowly. But other observa-

tions have shown that the reaction between water and metals, especially iron, is very highly affected by the temperature, which the author explains by the fact that within the region of temperatures used, the water is already nearly split into two ions, H and OH. The H ion helps the iron to pass into solution and the comparatively high concentration of OH then produces an immediate settlement of the iron ions in the form of an insoluble oxyduloxide. The hydrogen ions are then liberated as free hydrogen. This reaction is materially speeded by the presence of some electrolyte in the water or by contact of the reacting substances with some noble metal.

Experiments on small vessels have shown that by the application of this process, it is easy to have hydrogen continually discharged from the vessel under high pressure without permitting the water of reaction to come out from the vessel in the form of steam. The apparatus used for tests on

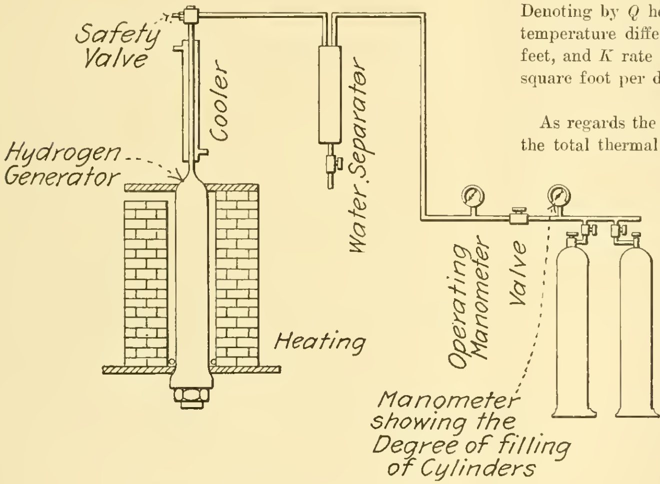


Fig. 5 Bergius Arrangement for the Generation of Hydrogen

a small scale is diagrammatically shown in Fig. 5. The vessel in which the reaction occurs is provided with a conical stopper, a narrow pipe serving as a return cooler. To this pipe is connected a second small vessel, the purpose of which is to catch water drops carried over by the gas mechanically while other piping leads to a high pressure container in which the hydrogen developed under high pressure is kept stored up. The experimental apparatus was filled with iron powder, water and some electrolyte and then heated up. Hydrogen was developed under a working pressure of 300 atmospheres, which happens to be a convenient pressure for use in various chemical processes where there is a demand for this gas.

The entire process requires only coal and water and compressed hydrogen is obtained without the utilization of special compressing plant. The hydrogen is stated to be purer than any other kind directly obtainable. (*Eine neue Methode zur Herstellung reinen komprimierten Wasserstoffs*, Dr. Fr. Bergius, *Zeits. für komprimierte und flüssige Gase*, vol. 17, no. 3, p. 33, March 1915, 6 pp., 3 figs., *d*).

# ENGINEERING SOCIETIES

## AMERICAN SOCIETY OF NAVAL ENGINEERS

*Journal, vol. 27, no. 2, May 1915, Washington, D. C.*

Heat Transmission and Tube Length in Marine Feed-Water Heaters, Leo Loeb (abstracted)
Steam Turbine Blade Fastenings, Jas. A. Capstaff
Possible Application of the Drzewiecki Method to the Design of Water Propellers, H. E. Rossell
The Pneumercator, Henderson B. Gregory

### Heat Transmission and Tube Length in Marine Feed-Water Heaters.

Investigation of the theory of heat transmission in feed water heaters and the elements affecting it. Reports of tests on Bureau of Steam Engineering heaters and Koerting film heaters.

Heat resistance is best measured in terms of its reciprocal, $K$, thermal conductivity, the number of heat units transmitted per unit of area across a given space per unit of time. Denoting by $Q$ heat transferred per hour in B.t.u., $t_m$ mean temperature difference, $S$ area of heating surface in square feet, and $K$ rate of heat transmission in B.t.u. per hour per square foot per degree of temperature difference, we have

$$Q = S\ K\ t_m$$

As regards the nature of $K$, it must be borne in mind that the total thermal resistance is dependent upon two film resistances, scale, and metal wall resistance. Proper preparation of the tube material and proper up-keep and operation will eliminate the scale condition. There are quite comprehensive data on the magnitude of metal wall resistance, which show that the temperature difference on the two sides of the metal tube is very small. Tube material or tube thickness only slightly impedes heat flow and a water film 0.00173 in. thick will give the same resistance as a 1-in. thickness of copper tube. It is evident, therefore, that a metal tube will transmit all the heat that is presented to its surface and the controlling resistances lie in the two films which cling to the metal surfaces, the resistance on both sides being much alike because the condensing steam presents a wet surface. The formation of such a film on the water side is a friction effect, the microscopic irregularities of the surface of the metal walls preventing the particles of water from being swept along with the major current. Hence the problem in producing high transmission in heaters is the destruction of this water film by a scrubbing action which may be produced by a high velocity along the heating surface, and after the limit of heat transmission has been reached on the water side by a velocity within practical limits, the controlling resistance passes to the steam side, so that the only way to further increase heat transmission is to sweep away the film on the steam side.

A factor in the heat transfer equation of equal importance with the coefficient of conductivity is temperature difference. It can be increased in but one way; by raising the temperature of the heating medium. Further, it is found that the increase in exhaust temperature obtained by throttling the auxiliary exhaust is also of some value.

The author then discusses types of temperature gradients resulting from various assumptions as to the functional dependence of heat transfer—for example, when a transfer is at any instant proportional to the temperature difference. He gives an analysis for this case and the curve obtained when inlet and outlet temperatures for a given steam pressure and water velocity are known. He shows, however, that

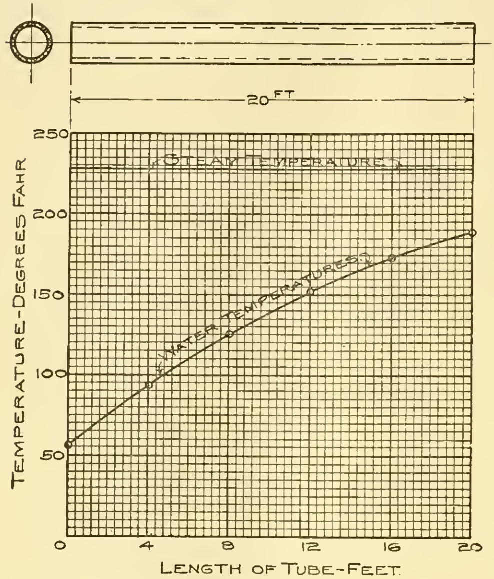


Fig. 6A. Temperature Gradient in a ¾ in. Copper Tube.

the analysis given would be very satisfactory were it not for the fact that there exists considerable experimental evidence that heat transfer in feed heaters is not directly proportional to temperature difference, and he proves it by results obtained from a single tube experimental heater tested under his own direction at the Engineering Experimental Station.

This heater consisted of a single ¾ in. copper tube, No. 18 B. W. G., 4 ft. long, secured within a 4 in. pipe which forms the steam space. The inlet could be regulated to any desired temperature by an auxiliary heater and the temperature gradients of any given water rate are determined by noting the inlet and outlet temperature at 3 min. intervals for a period of 18 min. In this way, in a heater the length of which could be varied to suit temporary conditions of velocity, the temperature could be determined at 4 ft. intervals. Table 2 gives data from a typical set of tests with the steam pressure of 5 lb. gage and the water velocity of about 4 ft. per sec.

The gradient corresponding to columns 2, 3 and 4 is plotted in Fig. 6A. Although the temperature rise per pass varies from 15.4 to 37.8, the average arithmetical temperature difference may be very closely considered to be the mean temperature difference per pass, since the curvature of the temperature gradient is very slight and the straight line connecting any two points varies only slightly from the best smooth curve through the points.

The relation between temperature difference and heat transfer per hour, columns 5 and 7 of Table 2, is plotted on logarithmic cross-section paper (Fig. 6C) and these points fall quite accurately on a straight line, which is equivalent to saying that heat transfer in feed water heaters is proportional to some power of the instantaneous temperature difference which may be expressed analytically as

$$Q = K\,S\,(t_s - t)^n$$

where $n$ is the slope of the line on the logarithmic curve, in this case, a value somewhat less than unity.

From this the author derives the following formula

$$t_m = \frac{(1-n)\,(t_o - t_i)}{(t_s - t_i)^{1-n} - (t_s - t_o)^{1-n}}$$

which is the same as that derived by Mr. Orrok for condensers, but is obtained from the basic experimental proof that heat transfer is proportional to a power of the temperature difference instead of the secondary fact that the rate of heat transmission per degree of temperature difference is proportional to a power of temperature difference. This latter method is more involved, inasmuch as it introduces another variable factor $U$, which varies with temperature, and there is a decided disadvantage in obtaining $U$ as function of $t$ because the whole purpose is to obtain an experimental value of $K$ which will remain constant throughout the heater design in question. A comparison of the two laws of temperature variation for the range of data in Table 2 is shown in the curves of Fig. 6B. The lines $A$, $B$ and $C$ are the gradi-

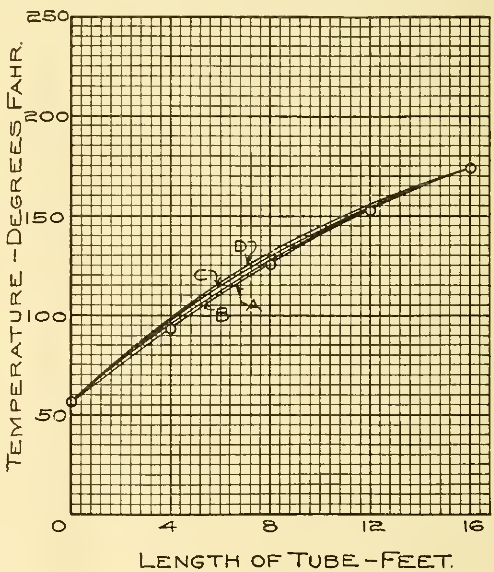


Fig. 6B. Curves Showing a Comparison of the Two Laws of Temperature Variation.

ents from the relation $l = c\,(t_s - t)^n$ where the values of $n$ are 0.7, 0.8 and 0.9. The line $D$ is the gradient from the relation $l = C \log_e (t_s - t)$ and the semicircles mark the inlet and outlet points in columns 2 and 3 of Table 2.

*Tests of Heat Transmission in Marine Heaters.* The above established general law for heat transfer was applied by the author to the test of heaters used in the naval service, two

types having been exhaustively investigated—namely, a feed heater designed by the Bureau of Steam Engineering for battleships 34 and 35, and incidentally used in evaporator plants on board ship; and a spiral corrugated film heater manufactured by Schutte & Koerting.

The Bureau feed water heater consists of a composition shell containing 117 semicircular ¾ in. tubes, No. 16 B. W. G. expanded into a composition tube sheet and a cast-steel bonnet, cast so as to form separate passages over the two ends of the tubes. When used for feed heating, the feed water passes through the tubes and the steam circulates in the outer casting. The total heating surface is 88.2 sq. ft., of which 86 sq. ft. is tube area. The net area through the water passage of tubes is .362 sq. ft. The data on these tests are only very briefly reported here because they were published in full in the Journal of the American Society of Naval Engineers, February 1912, pp. 155-166.

The tests were divided into two main groups, dependent upon the inlet temperature maintained at about 80 deg. fahr. in the first case and from 130 to 150 deg. in the second, with further subdivision, according to feed velocity and steam pressure. The mean water velocities chosen were 35, 71, 107, 143 and 171 ft. per minute. The steam pressures were 5, 10, 15 and 20 lb. gage and the water pressure was held at over 230 to 250 lb. gage. The tests show in general an increase of heat transfer with steam pressure and with velocity, but a decrease at the same pressure with increasing temperature difference. There were, however, irregularities in data which cast doubt on the results.

In some of the tests the tubes were fitted with retarders consisting of annealed copper strips ⅝ in. wide and 0.0268 in. thick, twisted into a spiral of 6 in. pitch. The dropping pressure through each pass of the heater is measured by a differential mercury gage, 0.55 in. of mercury without retarders as against 0.98 with retarders, which shows that the introduction of the retarders involves no serious increase in friction. The author finds that, for the heater in question, the heat transfer-temperature relations is given by $Q = K\ (t_s - t)^n$ where $Q$ = B.t.u. per hour per sq. ft. of heating surface; $K$ = a constant from experiment; $t_s$ = average saturation steam pressure within the heater; $t$ = water temperature; $n$ = a constant from experiment. Furthermore, $n$ is the slope of the curve on the logarithmic plot and has for this heater a value $n = 0.85$, which is independent of the velocity and of the use of retarders. The value of $K$, however, which is the intersection of the line prolonged and the vertical axis when $(t_s - t) = 1$ is dependent on the velocity and is therefore the function which varies with the greater or less removal of the water side film. The use of retarders has the same effect as increasing the velocity by increasing the value of $K$.

From data derived by Clement and Garland and published in a bulletin entitled "Study of Heat Transmission" (University of Illinois Engineering Experiment Station, Bulletin No. 40), the author comes to the conclusion that in a feed heater, the controlling resistance lies on the water side and is subject to correction by a mechanical agitating or mixing device up to the point where water ceases to flow as a uni-

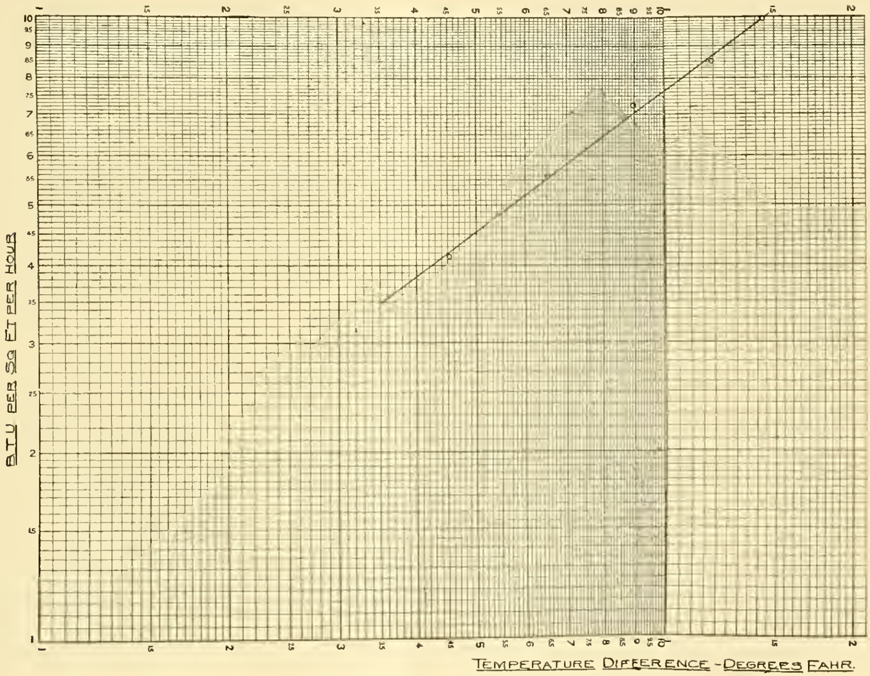


Fig. 6C. Heat Transfer—Temperature Relation of a ¾ in. No. 18 B. to Y. Tube.

form fluid, the point known as the critical velocity of the fluid.

As regards the use of retarders, the present tests have shown that in the Bureau type of heater, the introduction of the spiral retarders increased, at the water rate of 1500 lb. per tube per hour, the heat transmission by 16 per cent; at 2000 lb., 7.5 per cent; at 2500 lb., 14.9 per cent, and at 3000 lb., 14.8 per cent.

Further tests were made on a Schutte & Koerting spirally corrugated film heater of the usual type. In this heater, the water flows through in a 7/64 in. thick nominal film between two corrugated tubes, the steam circulating downward around the outer tube and within the inner tube. When the heater was put into service it was found that the least practical rate of discharge was 7500 lb. of water per hour, for at lower rates the outlet water was at such a high temperature that much of it was flashed into steam beyond the outlet control valve. As a result, the rates of discharge selected for this purpose were 7500, 10,000 and 15,000 lb. per hr.

The heat transmitted in B.t.u. per square foot per hour was found to reach a value of 147,922 lb. at the highest velocity, which corresponds to a heat transmission per square foot per hour per degree average temperature difference of 1.227 B.t.u., or more than double that obtained at equivalent velocities in the Bureau type of heater. However, the true velocity of water in this heater is not certain as the spiral corrugation will produce an agitation greater than direct flow through a uniform film of the same area. In every case the axial velocity was considered and the velocity corresponding to a reasonable friction loss would be about 250 ft. per minute, or 12,930 lb. of water per hr.

A small experimental heater of this type was tested at the Engineering Experimental Station in Annapolis in 1912. The experimental apparatus involved four pairs of spirally corrugated tubes arranged in two passes, the film thickness in the design finally adopted being approximately $\frac{3}{16}$ in. The heater was initially designed for horizontal installation, but a slight modification of the lower header permitted of vertical mounting. The article describes in detail the experimental apparatus and method of conducting the tests. No practical way was found to give an accurate temperature of the water at the reversal of flow in the lower head; hence a temperature gradient could not be constructed and the value of $n$ (exponent in the heat transfer relation) had to be determined indirectly. Since the temperature rise of test was usually in excess of 100 deg., the average temperature difference would not be close enough to the mean temperature to obtain the value of the exponent directly from the logarithmic plot.

It was found that only a slight advantage can be gained from water film agitation above 7500 lb. per tube per hour. This must be considered as the critical velocity for such construction and higher rates would produce no increased heat transfer, but would result in excessive friction losses. As regards the relation between the vertical and horizontal heaters of the same film thickness, at 500 lb. of water per unit of surface, the horizontal heater shows rates of heat transmission of 720 B.t.u. per hr. per degree of temperature difference as against 910 B.t.u. for the vertical heater, an advantage of 26.4 per cent. in favor of vertical installation. Care was taken to give the horizontal heater sufficient pitch to cause the water of condensation to flow freely from the tubes. This did not entirely accomplish the desired results, as the weights of condensed steam for the several intervals of any one test vary between wide limits, whereas in the vertical heater these quantities remain remarkably constant. The great difference between the performance of the horizontal and vertical heaters cannot, however, be entirely accounted for by the accumulation of water of condensation in the lower part of the corrugations of the inner tube, but the reason for the difference is to be found in the accumulation of air in the steam space, which cannot be eliminated by blowing through pet cocks in the covers. The presence of this air would actively reduce the transmitting surface, and this, taken with the irregular flow of water of condensation, would explain the variation. In a subsequent test, a more efficient disposal of air, attended, however, with a considerable loss of steam, resulted in rates of heat transmission of about 5 per cent less for the horizontal than for the vertical installation.

In the case of a 7/64 in. film vertical heater there is a noticeable lack of uniformity between the friction losses for high and low rates of flow, while the $\frac{3}{16}$ in. film gives uniform values of friction loss under widely varied temperature limits, and possesses the further great advantage of the re-

TABLE 2 TEMPERATURE GRADIENT IN A 3/4 INCH COPPER TUBE

| | |
|---|---|
| Outside tube diameter, inches | .750 |
| Inside tube diameter, inches | .655 |
| Length, feet | 4 0 |
| Water-heating surface, square feet | .6853 |
| Steam-heating surface, square feet | .7873 |

| No. | Steam Temperature, Deg. Fahr. | Water Temperature, Deg. Fahr. | | Average Temperature Difference | Water Heated per Hour, Pounds | Heat Transfer B.t.u. per Hour per Sq. Foot Steam Surface |
|---|---|---|---|---|---|---|
| | | Inlet | Outlet | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 228 4 | 55 6 | 93 4 | 143.9 | 2,070 | 99,060 |
| 2 | 228 0 | 93 2 | 125.2 | 118.8 | 2,095 | 85,039 |
| 3 | 228 4 | 125.1 | 152.3 | 89.7 | 2.106 | 72,771 |
| 4 | 228 1 | 152 5 | 173 4 | 65.1 | 2.120 | 56,007 |
| 5 | 227 3 | 174 4 | 189.8 | 45 2 | 2,106 | 41,453 |

placement of tubes without danger of change in adjustment sufficient to modify the nominal film thickness.

The author suggests, therefore, the standardization of the $\frac{3}{16}$ in. film vertical heater as being advisable, besides the important consideration of minimum friction loss, also because of equal heat transfer per unit of heating surface, efficient removal of water of condensation and non-condensible gases from contact with the heating surface, and ability to maintain a uniform film thickness when assembling the units (55 pp., 20 figs. *etA*).

## THE CONCRETE INSTITUTE

*Transactions and Notes, vol. 5, parts 3, 4, 5, 6, April, 1915, London*

- Some Fallacies in Cement Testing, W. Laurence Gadd (abstracted)
- Factory Construction in Reinforced Concrete, Percival M. Fraser
- Standard Method of Measurement for Reinforced Concrete (report)
- Calculations and Details for Steel-Frame Buildings from the Draughtman's Standpoint, W. Cyril Cocking
- Forms for Concrete Work, Allan Graham
- The Design of Steel and Reinforced Concrete Pillars, with Special Reference to Secondary and Accidental Stresses, Oscar Faber
- Sand and Coarse Material and Proportioning Concrete, John A. Davenport and S. W. Perrott

### Some Fallacies in Cement Testing

The paper discusses what the author refers to as fallacies in cement tests, or more precisely, various possible sources of error affecting the reliability of results obtained from such test. He starts with the stipulation of the British Standards Specification, that before any sample of cement is submitted to certain tests, " it shall be spread out for a depth of three inches for 24 hours in a temperature of from 58 to 64 deg. fahr." One of the possible objects of this procedure was to obtain conditions similar to those governing cement which has lain in sacks or casks for two or three weeks. In order to test the effect on certain types of storage in sacks, the author tested three sets of samples from specimens dispatched to him at the time of the filling of the sacks, and found that in the majority of cases, the cement became quick in initial setting after storage in sacks for 14 and 28 days, with some exceptions. The final setting was in some cases slowed and in others quickened, but it is impossible to generalize on the results so that the only thing one can say is that cement kept in sacks, under ordinary conditions of dry storage, may either become slower or quicker setting, but the results cannot be foretold.

Tests were also made to determine the effect of aerating in layers three inches deep. It was found that the setting time, tested in accordance with the British Standards Specification, does not agree with that of the bulk sample which it is supposed to represent. There is no relation between the effects of aerating cement for 24 hours and storing in sacks for two weeks or a month; the setting time is differently affected when the same cement is aerated or stored in bulk in different localities or at different periods. Changes in setting time are not due to some inherent property of different cements. The erratic behavior found is common to all the samples tested, the composition of which vary with considerable limits. The retardation or acceleration of setting time on storage or aerating must be due, therefore, to chemical changes brought about by the absorption of some constituents present in the mixture. To test this, a quantity of slow-setting cement was placed in a large glass tube and a current of purified air, free from ammonia, carbonic anhydride and moisture passed over it continuously for 24 hours. It was found that pure dry air had no effect upon the setting time of the cement, the loss constituents remaining practically constant. On the other hand, the effect of moist air, free from carbonic anhydride, was distinctly marked, although the percentage of moisture absorbed was comparatively small. The acceleration of setting time by carbonic anhydride was also clearly proved.

The author discusses also the question of fineness of cement in tests, and the exactness of the mesh of the sieve. He finds that sieves which conform to the British Standards Specification often give, in testing, most erratic results. Further, the size of the sieve itself has been overlooked, which is important because the same weight of cement, sifted for the same period of time will be more effectively sifted over a large area than over a small one. (Proved by actual experiment.)

The specific gravity test still retained in the British Standards Specification, is considered to be a test for underburnt cement, but gives really no indication of the degree of calcination. The author's experience is that, when cement is taken freshly from the kiln, the specific gravity is practically the same whether the clinker be well burned or underburned, provided the carbonic anhydride has been all, or nearly all, expelled from the chalk. The author thinks, therefore, that the test should not be retained because, first, the direct method of estimating the loss on ignition is more accurate than a determination of specific gravity, and second, an artificial cement, especially if finely ground, exposed to air, but kept in a damp store for some time, may have its gravity reduced to a figure quite as low as that of many natural cements. The only certain guide by which to determine whether a sample is or is not a natural cement is a chemical analysis and with the data this gives, the specific gravity becomes superfluous.

Tensile or crushing tests of cement with standard sand do not represent, in the opinion of the author, the best results of which the cement is capable but give results which are standardized and therefore comparable with those obtained by different operators. The crushing strength, especially of concrete or mortar, depends largely upon the size and character of the aggregate, the absence or presence of dust and clay matter, and the density of the mass. Experiments made by the author have shown that the crushing resistance of concrete, made from the same cement, varies not only with the size but also with the character of the aggregate.

The author is distinctly against the use of the so-called autoclave test, and claims that to show the utility of such a test it must be shown, further, that the cement which passes the simplest soundness tests generally employed will yet be dangerous in ordinary work, and second, that the autoclave test will detect such cements with certainty, neither of which points have been demonstrated so far.

Finally, the author rejects the widely accepted theory that unsoundness of cement may be due to free lime locked up within the particles of the ground material. The improvement in soundness brought about by the exposure of cement to a damp atmosphere might lend some apparent support to the contention that the freed lime is thereby slaked and rendered harmless; but he fails to see how the small amount

of moisture absorbed from the air penetrates the particle and slakes the free lime when the enormously larger quantity of water used in gaging the cement fails to do it. Furthermore, unsound cement stored for some time in air-tight receptacles, in which presumably no slaking of free lime can occur, still becomes perfectly sound. Finally, it is a well known fact that low-lime cement is often more unsound than high-limed cement, which is again antagonistic to the free-lime theory. The author's view is that unsoundness in cement is probably due to the presence of an abnormal silicate perhaps dicalcium silicate, which is an unstable compound and slowly disintegrates with an increase in volume (18 pp., *g*).

## TENTH ANNUAL CONFERENCE ON WEIGHTS AND MEASURES

Automatic Scales, F. J. Schlink

The paper, read before the Tenth Annual Conference on Weights and Measures of the United States, May 26, 1915, is abstracted from an advance publication in *The Scale Journal*, (Vol. 1st, No. 9, June 25, 1915, Chicago, Illinois).

The author divides weighing scales into two classes; viz., scales in which the weight of the load is determined by the manipulation of suitable balancing or equilibrating means, through the agency of an operator, and those in which the weight is obtained by merely placing the load to be weighed upon the scale and reading the indication of some self-actuated mechanism. Automatic scales, which is the generic name of scales of the second class, may be of many forms, such as scales in which the reading is obtained directly through the agency of a variable equilibrating element dependent in its action upon the magnitude of the load being weighed; scales which perform repeated weighings of a definite amount of commodity which, though fixed for a single setting of the scale, may be adjusted within a certain range (package scales or dumping scales).

As a means for obtaining automatic indications may be used either an elastic body, the deformation of which bears some known relation to the external force applied to it, or a system of non-elastic bodies having a definite configuration for a given magnitude and direction of the forces which are applied to it. The first class is exemplified in spring scales of which the helical or screw spring scale is the most common. All forms of springs are, however, subject to certain changes which affect their utility as weighing elements; among these changes are, first, imperfect elasticity, which results in the slight differences in the elongation of the spring at a given load, depending upon whether the load is being increased or decreased, and also upon by what are called fatigue effects; the effects of imperfect elasticity can be reduced to a minimum by using the spring at a low working stress. Second, error due to change of elastic properties and dimensions of the spring with temperature. This may be corrected or avoided by one of several methods, such as automatically changing the ratio of the leverage as the temperature changes. Another method is to keep the spring at a constant and definite temperature, and finally, to use springs made of special alloy steels.

Pendulum scales, strictly speaking, include also the lever system of an ordinary beam scale. The author describes in detail the pendulum scale in its simplest form, and the cam pendulum scale. The following considerations have affected the design of such scales: if the reading chart of a pendulum scale is divided into intervals which are not uniform, any change of level of the scale taking place in the plane of the pendulum will cause the pointer to start from a different point, and if the scale be rebalanced without being releveled, it will read inaccurately. If, on the other hand, the graduations are uniformly spaced, a slight shift of the level of the scale only changes the zero region of the pointer and an adjustment of the balance by the means provided for that purpose will cause the scale to read correctly. In practice, however, the frequent adjustment of the zero balance becomes troublesome and to avoid it, the double pendulum construction is used and a weighing scale practically free from changes of balance or weight indication from small shifts of level is obtained.

The third type of equilibrating element is the cam mechanism, which is an extension of the familiar wheel and axle principle. The author describes it in detail. The cam principle is frequently employed in connection with the pendulum system, and in many cases it is difficult to distinguish sharply between cam and pendulum scales.

Every pendulum scale in which the uniformity of graduation interval is secured by means of a cam and wrapping connector is an illustration of such a combination.

In a pendulum scale having a single pendulum there is generally no cam, or only one. In a cam scale there are two, one for connection to a counterpoise and one for connection to the platform levers or weight receiving system. To add the pendulum principle to such a cam system it is only necessary to establish the center of gravity of the cam outside the center of rotation. Then the applied weight of the load is resisted not only by the fixed weight of the counterpoise, but also by the weight of the cam body itself, acting also at a variable distance from the axis of rotation. There are, then, in action, two resisting forces, each obeying a different law, and to have equally-spaced graduation, the cam must be made of such contour as to suit the combination of these two effects. Practically, this means that in the construction of a scale which is intended to act upon the cam principle alone, there should be added a small weight, adjustable on an arm extending out from the cam body, so that, by shifting the arm and the weight upon it, the center of gravity of the cam body may be brought into the axis of rotation. Conversely, the center of gravity may be intentionally shifted outside the axis of rotation any suitable amount, in order to take advantage of the corrective effect which can thus be obtained.

From this, the author proceeds to the description of other parts of the automatic scale, such as the load receiving mechanism, i. e., the lever system, the indicating mechanism, and auxiliary devices, such as the damping and relieving mechanisms. The writer expressed a belief that, in the future, automatic scales will find a continually widening application in mercantile and industrial service, while modern methods of design and manufacture are sure to bring forth refinements in construction and extension of utility (6 pp., 7 figs. *dg*).

## FARADAY SOCIETY

*Transactions, vol. 10, parts 2 and 3, May, 1915, London*

The Vapor Pressure of Liquids in Presence of Gases, F. H. Campbell

The Hardening of Metals. A General Discussion (abstracted)

Opening Address, Sir Robert Hadfield

Introductory Paper, G. T. Beilby .

The Influence of Allotropy on the Metastability of Metals, and its Bearing on Chemistry, Physics and Technics, Professor Ernst Cohen
The Part Played by the Amorphous Phase in the Hardening of Steels, J. C. W. Humfrey
The Hardening of Metals by Quenching, Professor C. A. Edwards
The Hardness of Solid Solutions, Cecil H. Desch
Note on Crystal Twinning and the Martensitic Structure, Cecil H. Desch
The Interstrain Theory of Hardness, Andrew McCance
Hardening With and Without Martensitization, Professor Henry M. Howe
The Hardening of Steel, Professor J. O. Arnold

### The Hardening of Metals

A general discussion of the subject of the hardening of metals, at the Faraday Society, on November 23, 1914, in order to afford an opportunity for a further and fuller discussion of this important subject, somewhat briefly taken up at the last meeting of the Iron and Steel Institute.

Sir Robert Hadfield, in the chair, opened the discussion by a brief introduction in which, among other things, he spoke of a specimen of steel found in India, on good authority dating as far back as 125 B.C. Its interest lies in the fact that it is probably the first specimen of that age containing as much as seventy per cent carbon, which indicates that it can be readily hardened by heating and quenching in water. The material has been in its present condition for probably more than 2,000 years and now, after being heated and quenched, hardens exactly as if it had been made only yesterday, thus showing that notwithstanding this long interval and high surface oxidation, this specimen has undergone no secular change of structure or alteration in the well known capacity of an alloy of iron with carbon to harden under certain conditions.

Doctor G. T. Beilby read a paper on the hardening of metals, in which he indicated in a brief and general manner how hardening occurs and to what it is due.

Professor Ernst Cohen, of Utrecht, presented a paper on The Influence of Allotropy on the Metastability of Metals and Its Bearing on Chemistry, Physics and Technics. The paper reports an extensive and highly interesting investigation on electrolytic transformation of metals, in particular of bismuth, cadmium, copper, zinc, antimony, sodium, potassium and lead. The investigation as carried out involved the use of a pycnometer and dilatometer and of the electric potential method.

In previous experiments on bismuth, the writer found that metals may show very great retardation in undergoing molecular changes at temperatures either above or below their transition points. This reluctance to undergo change is probably one of the reasons why the phenomena observed by the writer have remained undiscovered until now. The experiments have shown that the same applies to cadmium; that cadmium is further able to undergo a reversible transformation; that apparently there may be several transition points at various temperatures and that it is very difficult, if not impossible, to fix the real transition point of the pure modifications. In order to prepare a sharply defined modification of cadmium, avoiding high temperatures, an extensive investigation of the electrolytic method, of considerable value in other directions, has been carried out. It is not reported here, however, because of lack of space.

As regards the phenomena observed in the investigations on cadmium, lead, bismuth, copper, zinc and antimony, the author concludes that the pure metals as we have known them until now, are metastable specimens consisting of two or more allotropic forms, which is a consequence of the very strong retardation which accompanies the reversible change of these allotropic modifications below and above their transition points.

The existing data on the physical constants of metal, unknown until now, are thus considered as entirely fortuitous values depending upon the previous thermal history of the material used. The physical constants which refer to a well defined condition of the metal are so far unknown, and as the phenomena described by the author have been unknown up to the present, metallurgists have not been able to take them into account in studying the hardening of metal, and yet these reversible transformations which often go on very slowly in consequence of the retardations mentioned above, must play an important role when the metals are subjected to changes of temperature. This role may become fatal if the metals are in contact with electrolytes (water, for instance) as this accelerates enormously the transformation velocity.

In an appendix, the author discusses further the question of heats of transformation of metals and the specific heats of different metals at different temperatures. Although the metals used by the author were of high purity and *cast*, which would indicate that the condition of the material was definite, it was found that previous heat treatment must still be taken into account and the values for the specific heats of these metals must be considered as fortuitous. From experiments on sodium it was found that sodium can be either monotropic or enantiotropic (a fact which was not previously known), and that it is possible to obtain at least a nearly quantitative yield through this stable or metastable solid modification from a metallic grade.

J. C. W. Humfrey presented a paper on the subject of the amorphous phase in the hardening of steels, in which he offered an explanation of the hardening of steels, using as a basis data of recent experiments upon the reflection of X-rays from crystal surfaces. The theory of crystal structure, as now accepted, asserts that the regularity of crystal structure within a crystal is two-fold, viz.:

*a* The centers of gravity of the molecules are arranged together according to one of a series of geometrical devices called "space lattices," in which each point in the lattice is surrounded by a similar distribution of other points.

*b* In each molecule of a crystal, the atoms are similarly situated.

The author considers that it is the second form of regularity which essentially gives rise to the first; or in other words, that in crystallization from fusion, it is the forces exerted by each molecule upon its neighbors (i.e. forces due to the resultant reactions of its atoms), which bring about the space-lattice structure of the crystal. The allotropic change must be considered as being essentially accompanied by a change in the internal structure of the molecule; e.g., a reorganization of the atoms composing them or a change in their number. Before this reorganization can be completed, however, there must be at least a temporary state of disorder, and it is during this disorder that the author considers that the structure must be looked upon as amorphous, and the intermediate amorphous state may be realized as corresponding to the liquid which would be formed by the fusion of the solid phase, stable at the lower temperature.

if the conditions could be so adjusted that the subsequent recrystallization were avoided. In certain cases, such phenomena can be actually observed, e.g., in the case of sulphur the changing from the monoclinic to the rhombic and back again normally occurs at the temperature of 95.6 deg. cent. In the case of iron, the temperature-tenacity curves obtained by Rosenhain and the present writer give strong indications that a similar phenomenon might occur and that if on heating a sample of iron, suitable conditions of pressure would be applied which prevented recrystallization to the $\gamma$, then a true melting point would be observed in the neighborhood of 900 deg. cent. That a second crystalline phase may form after the first is broken down to amorphous necessitates the condition that the mass is not too viscous or that it forces the crystallization to overcome the viscosity and to marshal the molecules into their new orientation. Beilby proved that such a condition is not invariably present, since any amorphous phase formed by severe overstrain in the cold possesses a definite stability up to certain well-marked temperatures and only passes back into the crystalline state when these temperatures are exceeded. In a metal in which an allotropic change normally takes place at a temperature well above that at which the viscosity is sufficient to prevent crystallization, abnormal conditions, such as rapid cooling, may delay the change to well below this temperature.

From experimental data it was found that while in the case of pure iron there is a range of about 400 deg. cent. between the temperatures at which the breakdown of the $\gamma$ iron occurs and that at which the recrystallization of the $\alpha$ iron becomes difficult, yet in the case of an 0.9 per cent. carbon steel, the range is reduced to less than 200 deg. cent. The probability of retaining by sudden cooling some of the amorphous phase formed by the breaking down of the $\gamma$ structure is therefore much greater with increasing carbon contents. Another factor causes the presence of carbon to still further promote the retention. Above the changing point, the carbide is in solid solution in the austenite, and when this phase breaks down to amorphous, the carbide molecules will still remain closely intermingled with those of the $\alpha$ iron. But before the amorphous can recrystallize, the two different kinds of molecules have to segregate, since the carbide is not soluble in either $\alpha$ or $\beta$ iron. Such segregation must necessarily be a slow process in an uncooled viscous mass and rapid cooling may easily allow the minimum temperature of crystallization to be passed before it has had time to take place.

## SOCIETY OF ENGINEERS

*Vol. 6, no. 5, May 1915, London.*

### Some Future Developments in Heating and Ventilation, A. H. Barker

A general discussion of the development of heating and ventilation with an exposition of the underlying difficulties in its way, and some suggestions as to the ways of overcoming them.

In the author's opinion the main difficulty in developing heating and ventilating engineering on a strictly scientific basis lies, first, in the great complexity of the problems with which one has to deal in every individual case, and next, in the fact that the object of both heating and ventilation, though primarily physiological, is also to some extent psychological. It is necessary to keep the inhabited rooms healthy, but of almost equal importance is the necessity of keeping them comfortable. Some physiologists say that it is desirable, in the interest of health, that the temperature maintained shall be as low as a human being can endure without real discomfort, while others claim that the rooms should be so warm that the man feels comfortable without any effort. No one can tell, say within 300 per cent. how much fresh air per head per hour is the minimum consistent with health, and the matter becomes still more complicated because of the baffling fact that a man is comfortable when he thinks he is comfortable; if we can make him imagine he is comfortable, without the alteration of any single condition, we can make him feel comfortable.

The room filled with air which is perfectly pure, as far as chemical analysis can detect, may *feel* very stuffy; for instance, the House of Commons' air in the debating chamber is chemically speaking as pure as in any room in the world, yet it produces without any possible doubt the lassitude and sleepiness, infection, etc.,—effects which we are accustomed to think of as connected with defective ventilation. On the contrary, a room may feel fresh and sweet in which, judging by chemical standards, the air is far from pure. There must be some combination of chemical and physical conditions, which accounts for the effect so far as it is objective, but nobody up to the present time has ventured to specify what that combination is.

The future of the sciences of heating and ventilation depends on the analysis of the conditions which produce the feeling of comfort and other effects. The criterion of success is a pleasing effect on the feelings of an individual, but we must, in order to get this subject on a scientific basis, be able to translate the feelings of an individual into terms of measurable physical conditions. The physiologist and hygienist have to specify what are the conditions that will be regarded as healthy and comfortable, and the only legitimate function of the engineer as such is to produce and control such specified conditions; for instance in the matter of heating, the practical problem before the engineer is to introduce heat into a building in such quantity and such form as to make the people comfortable. This can be done *either* by convection currents *or* by radiation, a fact which has received, so far, no proper recognition. Indeed it does not seem even to be generally clearly understood just what is meant by the expression "temperature of the room." Commonly understood, it means the reading of an accurate thermometer suspended in the room, but a thermometer suspended in a room does not indicate the temperature of the room surrounding it, as it is largely influenced by the great amount of radiant energy impinging on the bulb which has no connection with air temperature.

In this connection, the author mentions the fact that a good many people cannot endure radiator heat. It is absurd to believe that it is a "dry" heat, as it is no more dry than any other form of heat. Why then is radiator heat so distasteful to many persons? To answer this question, the author has introduced a conception which he has named "radiant temperature," the idea of which is that temperature which a thermometer would register if there were no air in the room at all, a sort of mean of the temperature of the surrounding walls. There are four differnt quantities—air temperature, radiant temperature, quantity of convected heat and quantity of radiant energy, which must be measured before one can answer the questions which come up in connection with various types of heating, and before that is

done, it is necessary to determine experimentally what is the relation between the thermometer reading, the air temperature and the radiant temperature. The author has devised for this purpose, several instruments of comparatively simple construction. One of them has as its object to ascertain what are the mean temperatures of the surfaces of the walls of the room, the furniture, and of the exposed surfaces, the temperatures of which have an effect on the bulb of the thermometer. The second instrument is for finding the actual temperature of the air. In this apparatus the radiant temperature is artificially made identical with the air temperature so that both are the same as the temperature reading.

The author claims to have proved by the aid of these instruments that the stuffy feeling which is often associated with systems of central heating is due largely, but not entirely, to the fact that the air temperature is too high and the radiant temperature is too low; the freshness of a building depends on keeping the air temperature relatively low and the radiant temperature high. It is the temperature and humidity of the air, which are the important points, and not its chemical freedom from $CO_2$ or other organic products.

At the University College in the Department of Heating and Ventilating Engineering, an effort is made to develop experimentally the law of pneumatics on a somewhat similar basis to that of electricity. A fundamental formula is taken in a form comparable to the Ohm's law, viz., $H = RQ^2$, and the validity of this law is experimentally tested in all kinds of pneumatic flow. To do this, special apparatus had to be devised, such as a large apparatus, a pneumatic analogue of the Wheatstone bridge, for the determination of specific resistance. This method is of great importance not only for the heating and ventilating engineer but also in many other lines; for example, specifying proper resistance in pneumatic units for a boiler flue or chimney will make it possible to deal on a rational basis with the problem of chimney shafts. By the application of such rules, we can determine what is the actual resistance of a boiler flue and what is the maximum capacity of a plant either in heat units or pounds of steam. To apply the method of power resistance to the determination of resistance of boiler flues and chimney shafts it is only necessary to attach a fan to the air inlet of the boiler through a chamber in which a constant low pressure of air can be maintained. An adjustable resistance between the fan and the boiler inlet is then allowed and the current measured in several cases, from which the pneumatic resistance can at once be established. In fact, it is even possible to determine the value of the resistance without a fan by having a very accurate micrometer gage, as the author shows. (40 pp., 8 figs. *gdA*).

### UNIVERSITY OF ILLINOIS

*Bulletin, vol. 12, no. 32, April 12, 1915, Urbana, Ill.*

A Study of Boiler Losses, A. P. Kratz.

Description of experiments undertaken to determine the conditions prerequisite for the continuous operation of the boilers in the new power plant at the University of Illinois and to permit a detailed study of the boiler and furnace losses, under varying conditions of load, depth of fuel bed and draft.

The boiler was operated as one of a battery of two boilers which delivered steam directly into the mains connected with the old plant. It was a Babcock & Wilcox boiler, designed to carry a working pressure of 160 lb. per sq. in. and having two 42 in. by 20.33 ft. drums and 18 sections of 4 in. tubes, 18 ft. long, each section containing 14 tubes. The stokers were of the chain grate type, having an active grate surface of 90 sq. ft. The arch was 15 in. above the grates at the front and 33 in. at the back. The draft was produced by means of a brick chimney 175 ft. high, having an internal diameter of 10 ft. With a few modifications, the methods employed in these experiments were those of the A.S.M.E. Code for conducting boiler trials.

In the items in the tables there are added to those of the boiler test Code of the A.S.M.E., data on three efficiencies, viz., the efficiency of furnace and grate; the efficiency of the furnace, and the efficiency of the boiler exclusive of the furnace and grate. This was done because the efficiencies given in the A.S.M.E. Code are over-all efficieucies for the boiler and furnace together and do not afford a means of determining whether a loss in the efficiency of a unit is due to poor furnace construction, dirty tubes or faults in the boiler itself.

The following conclusions are drawn by the author from his tests: As regards the relation between thickness of fire, capacity and efficiency, it was found that the best efficiency under full load conditions was obtained with a fire of about 7 or 7.5 in., as this seemed to give a fuel bed resistance such that the normal amount of coal can be burned without excessive draft. For each load there seemed to be a well-marked thickness of fire which gave the best efficiency and, as the load decreased, this also became less; thus, for 1.25 load, the maximum efficiency occurred with 8 to 8.5 in. fire; for full load with 7 to 7.5 in. and, for ¾ load, with about 6.5 in.

The over-all efficiencies obtained were not surprisingly high, as under normal conditions of load and fire the over-all efficiencies have been about 65 per cent. The efficiency of the furnace and grate was fairly constant for all loads and depths of fuel bed. The losses in efficiency at higher loads were due to reduced heat absorption by the boiler and, in general, the lower boiler efficiencies coincide with the higher temperatures. As regards the amount of draft necessary, it is determined by three factors: the thickness of the fire, the amount of dust in the coal and the horsepower development. The 9.5 in. fire was found to invariably require the maximum draft for any given load. With thinner fires, sometimes one and sometimes another require more draft, depending largely upon the amount of dust and slightly varying horsepower. Between the limits of 24 to 32 lb. per sq. ft. of grate surface, and with a normal thickness of fire of about 7.5 in., it requires a draft of approximately 0.01 in. of water per lb. of coal per sq. ft. of grate surface per hour to burn Illinois screenings.

The relation between load, combustion and horsepower developed may be represented by a straight line. The percentage of excessive air decreases to a minimum and then increases again as the thickness of the fire increases. With thin fires, there is a marked tendency toward the formation of holes in the fuel bed through which an excessive amount of air can pass. Also, the entire fuel bed is more open and porous. The air is therefore not brought into as intimate contact with the incandescent surface of the coal as it otherwise would be, which leads to an excess of air. For fires less than 7.5 in. thick, the excess air increases when the load or rate of combustion is increased if a constant depth of fuel bed is maintained, while for fires above 7.5 in. thick, the reverse is true (72 pp., 31 figs. *e*).

## MEETINGS

### MINNESOTA, MAY 10

A joint meeting with the A.I.E.E. was held at the University of Minnesota on May 10 at which Mr. Brillhart of the Minneapolis General Electric Company gave a paper on the Lake Nokomis Electric Dredge and H. F. Teetsell of the Waldorf Box Board Company gave a paper on the Application of Electric Drive to Paper Mills and Data concerning the Paper Industry. Both papers were illustrated with lantern slides.

### LOS ANGELES, JUNE 15

A meeting of the Los Angeles Section was held on June 15, it being a joint meeting with the Southern California Section of the A.S.C.E., the Los Angeles Section of the A.I.E.E., the A.S.C.E., the A.I.M.E. and A.S.C., The Southern California Chapter A.I.A. and the Engineers and Architects Association of Los Angeles. The subject of the meeting was Service of the Technical Man to the Community. The meeting was addressed by William Mulholland, Samuel Storrow and James A. B. Sherer.

### CINCINNATI, JUNE 24

A joint meeting of the Cincinnati Section, A.S.M.E., and of the Engineers' Club of Cincinnati was held on the evening of June 24, 1915. Instead of the usual paper, a discussion took place on The Relations between the Valuation of Public Utilities and the Determination of Rates. There were three leaders of the discussion.

Mr. J. A. Lilly presented the point of view of the consulting engineer. He gave an impartial resume of the development of the various public service commissions and of the differences in opinion in the methods of physical valuation of properties. He dwelt for some time upon the intangible nature of franchise values and cited a number of cases in which supposedly able and honest engineers varied widely in their estimates of a given property.

Mr. O. F. Shepard presented the point of view of the consumer, who has had engineering training and experience. Mr. Shepard felt that large differences in valuations and contests over rates would occur as long as human nature does not undergo a violent change.

Mr. F. R. Healey presented the point of view of those who have been actively engaged in the operation of public utilities. Mr. Healey contended that time franchises have a value, even at their expiration; that is, that the value of the business as a growing concern is a real asset.

While no local instances were mentioned by the leaders of the discussion, certain public rates that are before the city council gave an added interest to the remarks of various speakers. The meeting was attended by about 100 members and guests.

## NECROLOGY

### JAMES TAGGART HALSEY

James Taggart Halsey was born in Philadelphia, Pa., in 1854, and was educated at the Episcopal Academy in that city. He was apprenticed in the Pennsylvania Railroad shops at Altoona, following which the railroad placed him in charge of its signals, and he made a number of basic inventions of types of this railroad auxiliary. He resigned from service with the Company to take up a position with the Talbot Works, Richmond, Va., in which he continued for seven years. He later specialized in portable machine tools, maintaining a shop in Philadelphia. He was the inventor of the Halsey Motor Truck for trolley roads; this was a pioneer invention in this field, and one in which several prominent engineers displayed interest.

Mr. Halsey was elected to membership in the Society in 1885. He died in Philadelphia on April 27th, 1915.

### JOSEPH AUSTIN HOLMES

Joseph Austin Holmes was born at Laurens, S. C., in 1859. He was educated at Cornell University, from which he was graduated Bachelor of Science in 1881. He became professor of Geology and Natural History at the University of North Carolina in the same year and continued as such until 1891. He was State Geologist from 1891 to 1903. In 1904 he was appointed by President Roosevelt as Chief of the U. S. Geological Survey Laboratories for the testing of fuels and structural materials, rendering noteworthy services. President Taft appointed him in 1910 head of the newly-created U. S. Bureau of Mines, and under his management great progress was made in perfecting methods of saving life in mines. The chief work of the Bureau under his direction has been the investigation of the cause of coal mine explosions, and one of his most important discoveries was that the dust from bituminous coal was more dangerous to miners than firedamp.

He received the degree of Doctor of Science from the University of Pittsburgh, and also of Doctor of Letters from the University of North Carolina, both being conferred upon him in recognition of effort in the mining industry.

He was a member of the American Institute of Mining Engineers, American Society for Testing Materials, the National Conservation Commission, and other organizations.

He was elected to membership in the Society in 1908. He died on July 13, 1915.

### THOMAS DYSON WEST

Thomas Dyson West was born in Manchester, England, in 1851, and was the son of a neice of Dr. Michael Faraday. He was brought to America in childhood. At the age of twelve, he began the practical study of engineering at the Portland Locomotive Works, Portland, Me. In 1887, he organized the Thomas D. West Foundry Company, now known as the Valley Mold & Iron Company, of Sharpsville, Pa., and ten years later he founded the West Steel Casting Company. He was vice-president and general manager of the former until 1909, and was chairman of the board of directors of the latter until the time of his death.

Mr. West was the author of many books and papers on practical foundry work, publications which were basic in foundry literature and included "American Foundry Practice," "Moulders' Text Book," etc.

He established and used American Foundrymen's Standardized Drillings, which was taken over by the U. S. Bureau of Standardization in 1905. He was also the pioneer of the Safety First movement, and he organized the American Anti-Accident Society.

He was a member of the American Society for Testing Materials and was president of the American Foundrymen's Association in 1905-6. He was elected to membership in the

Society in 1884, and he died in Cleveland, Ohio, on June 18, 1915, from injuries received in an accident.

AUSTIN LORD BOWMAN

Austin Lord Bowman was born in Manchester, N. H., in 1861. He studied engineering at Yale University, and was graduated with the degree of Bachelor of Arts in 1883. For four years he specialized in construction and bridge work for western railroads, and in 1887, he came East and took up similar work with the Norfolk & Western Railroad. From 1890-1895 he was engineer and superintendent of construction for the American Bridge & Iron Company, Roanoke, Va. In 1897, he established himself in New York City as a consulting engineer on heavy railroad work. For six years, beginning 1901, he was consulting bridge engineer for the Central Railroad of New Jersey, reconstructing most of the important bridges on that road. In December 1907 he became consulting engineer of the Department of Bridges of New York City, and last summer was made chief engineer of the Department, a position which he retained until his death.

Mr. Bowman was a member of the American Society for Testing Materials, American Railway Engineering & Maintenance of Way Association, and the New York Railroad Club. He was a member of the American Society of Civil Engineers and a director from 1905-1907. He was elected to membership in the Society in 1899. He died on June 3, 1915.

## PERSONALS

Maynard D. Church has accepted the position of assistant engineer of the Terry Steam Turbine Company of Hartford, Conn. He was until recently associated with the Dayton Turbine Pump Company, Cleveland, O., in the capacity of chief engineer.

Alfred J. Ormston, Jr., has accepted a position with the Jones & Laughlin Steel Company, Woodlawn, Pa., in the steam engineering department.

Alfred C. Brown, for the past four years general supervisor of equipment with the Edison Lamp Works of the General Electric Company, Harrison, N. J., has accepted the position of works manager with The Hopkins and Allen Arms Company of Massachusetts, factory located at Norwich, Conn.

F. H. Newell, consulting engineer U. S. Reclamation Service (Director 1907-1914, Chief Engineer, 1902-1907), has accepted the position of head of the civil engineering department of the University of Illinois, Urbana, Ill.

Lawrence B. Webster has completed his duties as engineer for the Committee on Appraisals of the Ohio Electric Light Association and has severed his connection with the American Gas and Electric Company of New York. He is now associated with Mandelbaum, Wolf and Lang, Cleveland, Ohio, managers of public utility and mining properties.

Richard C. Collins until recently connected with the United Shoe Machinery Company, Beverly, Mass., as mechanical engineer, is now associated with the Chelsea Fibre Mills, Brooklyn, N. Y., in the capacity of mechanical superintendent.

William H. C. Ramsey has accepted the position of general manager of The York Water Company, York, Pa. He was until recently associated with the Johnstown Water Company, Johnstown, Pa., in the capacity of superintendent.

Alfred S. Richardson has just completed a hydroaeroplane, of his own invention, which weighs 2300 lb. and has 2 six-cylinder Emerson engines of 68 actual h.p. each. The machine is the largest of its kind ever constructed and has two sets of planes, arranged in tandem, on each side.

The University of Toronto has recently conferred the new degree of D.Sc. upon T. Kennard Thomson. It is the first official recognition that the University of Toronto has shown a man in the engineering profession.

## STUDENT BRANCHES

CORNELL UNIVERSITY

At a meeting of the Cornell University Student Branch on June 28, the following officers were elected for the following year: A. R. Cota, president; W. H. Rice, vice-president; W. F. Courtney, secretary and W. W. Robertson, treasurer.

KANSAS UNIVERSITY

The last meeting of the year of the Kansas University Student Branch was held on May 20 at the home of Prof. A. H. Sluss. The following officers for the coming year were elected: Jerry Stillwell, president; Burnette Bower, vice-president; A. J. Nigg, corresponding secretary; Charles Hagenbuch, recording secretary; Walter Pickering, treasurer; G. A. Rathert, chairman of the Program Committee; and Jerry Stillwell and S. E. Campbell, representatives on the Governing Board of Associated Engineering Societies.

STATE UNIVERSITY OF IOWA

The following officers have been elected for the coming year by the State University of Iowa Student Branch: C. W. Harrison, chairman; Max Kalen, vice-chairman and Victor Johnson, secretary and treasurer.

## EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

### POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. In sending applications stamps should be enclosed for forwarding.*

07 Chief draftsman to take charge of engineering department of St. Louis concern; man of sufficient ability and commercial experience to make success of the position; executive, with fundamental training in practical mechanical work of modern drawing office, machine shop, pattern shop and foundry practice, but must be commercial executive.

030 Agency wanted for small patented electrical device of foreign invention. Apply by number.

068 Young Engineer to take charge of tool department of Massachusetts concern manufacturing sterling silver hollow ware; one who understands machine shop practice generally, but more particularly a man familiar with up-to-date methods of working sheet metal, such as rolling, cupping, drawing and spinning; will have charge of laying out the tools to manufacture the goods, supervise the making and operation of the tools; knowledge of up-to-date methods of shop practice of advantage. Position has a good future for the right man.

069 Steam specialty salesmen who desire to take on a line of vacuum heating specialties can arrange for representing manufacturer. Representatives wanted in several leading cities. Apply through Society.

0101 Large manufacturing concern wishes to engage as employment head a man of special ability in the selection of labor; would be permanently located at the factory and should be able to select men of proper character, who would have the training for the work carried on in the various departments. State age, experience in full and salary wanted. Location Philadelphia. Name confidential.

0108 Head superintendent, for large European concern thoroughly posted in the manufacturing of rubber shoes, technical and surgical articles, covering for rollers, tubes of all kinds, balls, toys and similar articles to be made of hard or other rubber, etc. Apply by letter.

0116 Man who has had practical mechanical engineering education, with knowledge of electrical engineering, machine shop work, drafting, etc., desires technically educated assistant in the further development of plans for constructing an improved rock tunneling machine. Location New York.

0136 Good opportunity for first class designers; men with drawing office experience needed, particularly on heavy machine tools and similar machinery. Location, Pennsylvania.

0171 Competent designer for cane sugar machinery for large manufacturing concern. None but thoroughly experienced men need apply. State age, experience and salary expected. Give references. Location New York.

0172 Assistant works manager for Michigan firm manufacturing cranes and electrical specialties. Applicant must be high grade in ability and personality, with experience in structural, mechanical and electrical work and modern manufacturing methods. Name confidential.

0174 Capable man to take charge of manufacturing department of Massachusetts concern. Experience not expected in particular line of work, which is the manufacture of spectacles and eyeglasses, but some manufacturing experience required on small accurate work. Applicant must show that he has ability to handle men and get results at a fair cost. Salary $1800 per year. Apply by letter.

0176 Power transmission salesman for New York concern manufacturing pulleys, shaft-couplings, collars, etc.

0177 Engineering draftsman who can handle general power plant work. Technical school man who has had three or four years experience in an engineering office. Location New Jersey.

0180 Firm of constructing engineers desires to add to its staff several good mechanical and electrical engineers. Location New England. Name confidential.

0181 Shop superintendent experienced in deep drawing of brass wanted for concern in New York State. Apply by letter.

0184 Superintendent of a shop employing one hundred and fifty men in the forging of steel tools; will have complete charge of the manufacturing and labor and should be able to plan and lay out new work. Initial salary $2000 to $2500. Subsequent figure will depend entirely upon results obtained. Location East. Apply by letter. Name confidential.

0188 Chief draftsman on steam or gas engineering. Location Jersey City, N. J.

0189 Draftsman for industrial and power plant, layout of machinery and structural building design. American. Salary $150 a month. Location Pennsylvania. Name confidential. Apply by letter.

0190 Foreman for European concern (listed in 0108) manufacturing articles of hard or other rubber. Apply by letter.

0192 Production Engineer or mechanical superintendent for pulp mill; man with technical training and practical experience; one who is familiar with modern methods of machine shop management. Name confidential. Apply by letter.

0195 Assistant Professor in department of mechanical engineering. Salary $1500. To teach Machine Design and allied subjects. Must have completed a course in mechanical engineering; some practical experience as well as successful teaching experience. Location Texas.

0197—Wanted—Engineer, assistant required for large maintenance department experience, along lines of power station work, millwright and piping, drafting and cost estimating. Position pays $20 to $25. Location Massachusetts. Replies must be written on one page and confine answer to the following: name; age; nationality; education; experience; references.

0198 Instructor in mechanical laboratory work. Salary $1,000 for the college year, with prospects of some increase if engagement is renewed at the end of the year. One who has had some teaching experience in the line indicated. Location Middle West.

0199 Young refrigerating engineer, preferably one who has had some experience in the field, as a salesman and a general man with engineering knowledge to call and talk things over with customers; until the man's ability has been proved, salary ranging about $25 per week. Location Ohio.

## MEN AVAILABLE

*The published notices of "men available" are made up from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.*

H-206 Junior member, mechanical graduate 1907, experienced in advertising and publication work, is open for position as publicity agent or advertising manager. Moderate salary at beginning if position is desirable otherwise.

H-207 Mechanical engineer, well qualified by technical education, experienced in research along lines of engineering physics, desires position involving industrial research or experimental engineering. Would also consider position as salesman on the road.

H-208 Member, mechanical and electrical engineer, formerly U. S. navy inspector, eleven years experience in design and construction of power and industrial plants, testing machinery, technical writing, desires change, preferably with New York consulting engineer or contractor. At present employed.

H-209 Member, age 42, graduate of Stevens Institute of Technology, 1893, with fifteen years general experience, from draftsman up through executive management, followed by seven years specializing in organization and efficiency work in both manufacturing and commercial ends in a wide variety of lines, including manufacture of chocolate, machine shop, underwear, wholesale news distribution, brass goods, foundry, paper boxes, printing and publishing, to avoid continual traveling, desires a permanent connection with a progressive concern, location preferred New York or vicinity. Will invest if conditions are favorable. Available about October 1st.

H-210 Member, Cornell graduate, age 31, married, eight years experience in refrigerating engineering, design and supervision of heat, light and power plants, desires position with consulting engineer or with private firm.

H-211 Member, who has specialized in elevator and hoisting machinery, including motor and control, also conveying and handling machinery and the special structure required in this line, experienced in drafting room, shop, field and estimating, desires position as executive or sales engineer. Can take up sales proposition with technical or non-technical customers and see the work through to completion.

H-212 Member, mechanical and electrical engineer, twelve years experience as combustion engineer, power house tester,

chief electrician and mechanic, desires position. Location immaterial. Speaks Spanish fluently.

H-213 Student member, 1915 graduate of Columbia University, in mechanical engineering, desires a position in or around New York which offers an opportunity to start in the engineering profession. Salary secondary consideration.

H-214 Junior, power and designing engineer, seven years practical experience in power plant design and operation, heating, ventilating, electric light and power, refrigeration, fire protection, reports, plans and specifications, desires position.

H-215 Member, graduate M.E., age 35, ten years in an executive position as technical writer and correspondent of technical subjects of a consulting engineering nature, teaching experience, also experience as practical machinist. At present employed, but open for engagement.

H-216 Junior member, M.E., five years experience in design and manufacture of stationary oil engines, two years experience in power plant work and general equipment, desires position with consulting engineer. Will consider any opening which may lead to responsible position. Location immaterial.

H-217 Graduate, Massachusetts Institute of Technology, successful in organizing in both production and business departments, is qualified to assume responsibilities of manager or assistant in plant where special executive capacity and manufacturing experience are required.

H-218 Technical graduate, age 33, ten years experience in boiler manufacture and general plate work, desires position as manager or assistant manager. At present employed.

H-219 Associate-member, age 27, Stevens graduate, six years experience in gas engine, designing, experimental, testing, and every department of machine shop, desires position as assistant to executive or other responsibility.

H-220 Associate-member, Cornell M.E., age 32, four years experience steam and efficiency engineering, one and one half years as master mechanic, capable of handling men, now holding manufacturing executive position, desires chance for more rapid advancement.

H-221 Student member, technical man, Purdue University, age 26, engineering experience, with initiative and executive ability, desires position as sales engineer or assistant to chief engineer. Location middle West preferred.

H-222 Associate-member, technical graduate, nine years practical experience in foundry, machine shop and assembling work; time study and time setting for prominent machine tool manufacturer, now employed traveling as high speed expert and adviser, desires position as superintendent or similar executive where opportunity is offered to acquire an interest in the business. Location preferred middle West.

H-223 Mechanical engineer, five years practical experience in steam turbines, power plant equipment, and layouts, also construction work and reinforced concrete, desires permanent position. At present employed.

H-224 Junior member, Stevens graduate, desires to associate with engineering firm or patent attorney. Opportunity for future considered before salary.

H-225 Junior member, age 27, graduate in mechanical engineering, three years experience in testing and operation of power plants, several years in editorial and office work, desires position as secretary or assistant to manager. At present employed. Location preferred New York.

H-226 Student member, 1914 M.E. graduate, desires position in engineering or experimental department of company manufacturing corn harvesting machinery or other agricultural implements. Location preferred middle West. At present employed in gas tractor company.

H-227 M.E. specialized on combustion of soft coal, has had experience as machinist, draftsman, engineer of coke works and chief engineer of large manufacturing concern, desires position with boiler, stoker or furnace manufacturer.

H-228 Student member, 1915 M.E. graduate, two years accounting experience, also field work on dredging machinery, drafting and salesman, desires position with manufacturing concern with chance for advancement. Location preferred New York or New England states.

H-229 Member, age 33, twelve years experience, six years with present company, is seeking position with opportunity for advancement, as mechanical engineer or charge of drafting room. Has good designing ability.

H-230 Member, graduate engineer, age 35, American, capable designer, practical foundry and shop man, experienced in modern production methods and management, has had broad engineering experience in Europe and America as mechanic and executive in design and manufacture of engines, heavy machinery, machine tools, automatic machinery and light high grade specialties, desires position as chief engineer, superintendent, manager or assistant. Location immaterial, salary commensurate with position.

H-231 Graduate M.E., at present employed as sales engineer and designer in heating and ventilation and power plant lines, thoroughly acquainted with vacuum heating systems, desires position in the same or along similar lines.

H-232 Graduate mechanical engineer, age 28, five years practical work prior to college course and two years subsequent thereto, wishes a teaching position in Eastern or Southern college or university in experimental engineering, mechanics or physics.

H-233 Japanese member, graduate of electrical and mechanical school in 1903, connected with telephone and railroad companies of New York City, intending to visit Japan next autumn, wishes to communicate with American firms planning to develop their business in Japan or China. Will consider agencies or commission. First class references will be furnished responsible parties interested.

H-234 Member, age 45, designing engineer and master mechanic, American, speaking French and German, desires position. South preferred. At present employed.

H-235 Member, with an unusually thorough experience in manufacture, and first class record as executive, at present in successful consulting practice in scientific management, and especially successful in developing capable men, desires manufacturing executive position.

H-236 Superintendent, twenty years mechanical and executive experience on small interchangeable work, competent to design tools and fixtures for increasing production and reducing costs. At present employed.

H-237 Member, age 33, married, graduate of the United States Naval Academy, several years active service in the United States Navy, desires operating executive position with manufacturer of arms and ammunition. Salary $4,000. Location immaterial. At present employed.

H-238 Junior member, Columbia graduate M.E., 1913, two years experience in production and drafting departments, desires position in New York with chance for advancement. At present employed.

H-239 Member, in consulting practice, with broad experience in perfecting general organization of manufacturing companies and in efficient operation of plants, including familiarity with various processes of manufacture, particularly metal working, is open for temporary or permanent connection. Under suitable conditions will take stock or interest in profits as part compensation for services.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Carnegie Endowment for International Peace. Pamphlet nos. 4-20. *Washington, 1915.* Gift of Carnegie Endowment for International Peace.

Chicago Railway Terminal Commission. Preliminary Report submitted to City Council Committee on Railway Terminals, March 29, 1915. Gift of John F. Wallace.

Chicago Traction. Board of Supervising Engineers. 6th Annual Report, 1913. *Chicago, 1915.* Gift of Bion J. Arnold.

City of New York. Bureau of Buildings. Report, 1914. New York. Gift of Bureau of Buildings.

"Hütte" des Ingenieurs Taschenbuch. Herausgegeben vom Akademischen Verein Hütte E. V. 22d edition. 3 vols. *Berlin, William Ernst & Sohn, 1915.* Gift of Publisher.

This, the most extensive of all engineering handbooks, is a monument to German thoroughness. The three volumes of a thousand pages each contain tables, diagrams, formulae and data on every conceivable engineering subject, and all are very carefully indexed. W. P. C.

Illinois Society of Engineers and Surveyors. 30th Annual Report, 1915. *Wheaton, 1915.* Gift of Illinois Society of Engineers and Surveyors.

Industrial Resources and Opportunities of the South. By Arthur D. Little. *Boston, 1915.* Gift of Author.

Industrielle Gesellschaft von Mülhausen. Jahresbericht, 1914. *Strassburg, 1915.* Gift of Industrielle, etc.

National Foreign Trade Convention. 2d Official Report, 1915. *New York City, 1915.* Gift of Robert H. Patchin.

Official Tests of 340 Horse Power Water Tube Boiler and Auxiliaries. (Report.) Harrison Street Pumping Station. *Chicago, March 20, 1915.* Gift of City of Chicago Public Works.

Oregon Agricultural College. The Trail Blazers. *Corvallis, Ore.* Gift of College.

Pipe Distribution Systems, N. S. Hill, Jr. Reprinted from Journal of the American Water Works Association, March, 1915. Gift of Author.

Frederick W. Taylor, Memorial. Spoken at Cedron, Indian Queen Lane, Germantown, Philadelphia, March 24, 1915. Gift of Morris L. Cooke.

Western Railway Club. Official Proceedings. Vol. 26. *Chicago, 1913-14.* Gift of Western Railway Club.

### GIFT OF ALFRED O. BLAISDELL

United States Navy. Marine Engines for Screw Propulsion, drawn by A. O. Blaisdell. Brooklyn, 1909.

Mr. Blaisdell, who presents these drawings, was connected with the Bureau of Steam Engineering at the Brooklyn Navy Yard, for a number of years. The drawings are Mr. Blaisdell's own work, being copies of scale drawings of all the marine screw engines of the United States Navy from the time of the Princeton to the Miantonomah. These are all drawn to the scale of ¾" to 1 foot, with a lettered description of each. They are a distinct contribution to the early history of marine engines in this country.

The Argument of Edward N. Dickerson, with his notes and explanations; the charge of Judge Nelson, and the verdict of the jury, in the case of Sickels vs. Borden. *New York, 1856.*

The Stevens Battery, 1850-1875.

### EXCHANGES

Institution of Civil Engineers. Minutes of Proceedings. Name Index. vols. LIX-CXVIII. *London, 1912.*

National Association of Cotton Manufacturers. Transactions No. 97, 1914. *Boston, 1915.*

Society of Naval Architects and Marine Engineers. Transactions, vol. XXII, 1914. *New York, 1915.*

### TRADE CATALOGUES

Berger, C. L., & Sons, *Boston, Mass.* Handbook and Catalog. Engineering, surveying, and mining instruments. *1915.*

Berkshire Mfg. Co., *Cleveland, Ohio.* Berkshire air squeezers.

Cleveland Twist Drill Co., *Cleveland, Ohio.* Drill chips, *July 1915.*

Flannery Bolt Co., *Pittsburgh, Pa.* Staybolts, *July, 1915.*

General Electric Co., *Schenectady, N. Y.* Bulletin no. 47050. Standard unit direct small plant switchboard panels. *May 1915.*

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## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

### ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

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*St. Louis:* Edward Flad
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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal

# THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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## COMING MEETINGS OF THE SOCIETY

*September* 16 and 17, *San Francisco, Cal.* In common with the other national engineering societies, professional sessions will be held in San Francisco, September 16 and 17, previous to the meetings of the International Engineering Congress, which will occur during the week of September 20. Papers will be presented on the Exhibits and Engineering Features of the Panama-Pacific International Exposition, and on Oil Engines, with special reference to their use with California oils. The sessions will be held in the Hall of the Native Sons of the Golden West, Mason Street, between Geary and Post Streets. The headquarters of the Society will be at the Clift Hotel.

*October* 6, *St. Louis, Mo.* Subject: The Little River Drainage District, by William A. O'Brien.

*October* 27, *St. Louis, Mo.* Subject: Telescopes, by Dr. John A. Brashear.

*Annual Meeting, December* 7–10, *New York City.* Arrangements have already been perfected for sessions by the sub-committees on Railroads, Textiles, and Protection of Industrial Workers and it is expected that papers will also be contributed by the Committees on Machine Shop Practice, Industrial Buildings, and Air Machinery, besides the usual miscellaneous papers. The Railroad session will be devoted to a discussion of trucks for passenger coaches. The Textile session will have papers by engineers prominent in the textile field on the relative values of purchased electric current, and of power from individual plants; hot water heating for textile mills; and the engineering features of insurance. The session on Safety Methods will be of interest to engineers generally. It is planned to have a discussion along broad lines, taking up the principles involved and the results obtained by safety methods, and their bearing on industry as a whole.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 September 1915 Number 9

# THE SAN FRANCISCO MEETING AND THE INTERNATIONAL ENGINEERING CONGRESS, 1915

As the time approaches for the September meeting and the International Engineering Congress, interest is centered on the programs of papers to be presented and on the other activities that have been scheduled. A complete account appeared in the August issue of The Journal of the preliminary affairs in connection with the meetings, such as the transportation arrangements, the headquarters and hotel accommodations, the meetings of other societies, the excursions, the Exposition, etc., but little was definite relative to the program of the meetings at that time. The programs of both the September meeting of the Society and of the International Engineering Congress have now been established and they are presented herewith in complete form.

> **PROGRAM OF THE SEPTEMBER MEETING**
>
> *Headquarters at Clift Hotel, San Francisco, September 16 and 17.*
>
> *Meetings in Hall of the Native Sons of the Golden West, Mason Street, between Geary and Post Streets.*
>
> THURSDAY, SEPTEMBER 16.
>
> Address of welcome by a leading citizen of San Francisco and response by the Vice-President, G. W. Dickie.
>
> ENGINEERING FEATURES OF THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION, G. L. Bayley.
>
> MECHANICAL ENGINEERING AT THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION, G. W. Dickie.
>
> FRIDAY, SEPTEMBER 17.
>
> THE HEAVY OIL ENGINE, ITS PRESENT STATUS AND FUTURE DEVELOPMENT, A. H. Goldingham.
>
> THE DIESEL ENGINE AND ITS APPLICATION IN SOUTHERN CALIFORNIA, W. H. Adams.
>
> THE STRENGTH OF GEAR TEETH, G. H. Marx and L. E. Cutter.

### TRANSPORTATION

As announced in The Journal for August, arrangements have been made for a special train from New York to San Francisco, for members of the Society and their friends, leaving New York (Grand Central Terminal) on Thursday, September 9, at 7.45 P.M. The train will stop at Niagara Falls for four hours on Friday morning, to permit of sightseeing. On Sunday morning the party will arrive at Colorado Springs, where side trips may be made to Crystal Park, Pike's Peak, Garden of the Gods, Cheyenne Canyon and the Seven Falls. The Grand Canyon will be reached on Tuesday morning and fifteen hours will be spent there, giving ample time for excursions to Bright Angel Trail, Bottom of Canyon, Hopi Point, Hermit Rim Drive and Sunset Point. The party will arrive at San Francisco on Wednesday, September 15, at 9 A.M.

Reservations for this train are now being arranged by Mr. G. S. Harner, Passenger Agent, New York Central Lines, 1216 Broadway, New York City. The fare to San Francisco by this train and return by any route (except via Northwestern points) is \$98.80. Pullman rates, one way, are quoted as follows: lower berth, \$22.00; upper berth, \$17.60.

For those members of the Society who cannot join the party from New York, reservations are being made on the Sunset Limited, leaving New Orleans on Sunday, September 12, at 11 A.M., and arriving in San Francisco at 1.00 P.M. on Wednesday, September 15. Accommodations on this train can now be secured by addressing Mr. J. H. R. Parsons, General Passenger Agent, Southern Pacific Company, New Orleans, La. The round trip fare, New Orleans to San Francisco, is \$57.50 going and returning over the same route. Pullman rates, one way, are quoted as follows: lower berth, \$11.50; upper berth, \$9.20.

### HEADQUARTERS

The headquarters of the Society will be the Clift Hotel, at the corner of Geary and Taylor Streets, San

Francisco. For members who desire to be accommodated at this hotel, a number of rooms have been arranged for at a rate of \$5.50 per room, including bath, to be occupied by one or two persons. Each member should make his own reservation direct with the hotel, mentioning the Society.

For convenience, the rates at other hotels as quoted to the Society are given below:

Palace Hotel, Market and New Montgomery Streets, \$4.00 per day, room and bath, one person.

Fairmont Hotel, California and Mason Streets, \$4.00 per day, room and bath, one person.

Hotel St. Francis, Geary and Powell Streets, \$7.00 per day up, room and bath, two persons.

Hotel St. Regis, 83 Fourth Street, \$2.50 per day up, room and bath, two persons.

Information regarding accommodations at any other hotels may be obtained by addressing the Official Exposition Hotel Bureau, 702 Market Street, San Francisco. This Bureau also undertakes to make reservations in approved hotels without charge.

It is also worthy of note that the Committee on Local Affairs in San Francisco has placed its services at the disposal of all engineers resident within the United States, so that those who visit San Francisco with their families and friends may be sure that special attention will be paid to their comfort.

### INTERNATIONAL ENGINEERING CONGRESS, 1915

The efforts of the Committee of Management of the Congress have been indefatigable to secure the success of the enterprise by the coöperation of members from the national engineering societies. The last report of this committee announced that practically three thousand members had been enrolled and 240 papers have been received.

Members of the Society still have an opportunity of enrolling in the Congress if they desire to do so. The fee, which is five dollars, entitles the subscriber to a certificate of membership, to participation in the deliberations of the Congress, to an index volume of the Proceedings, and to one of the volumes to be published by the Congress. Remittances may be made to W. A. Cattell, Secretary, Foxcroft Building, San Francisco.

The Congress will publish ten volumes of proceedings on the topics under which the program is divided as follows: The Panama Canal; Waterways, Irrigation; Municipal Engineering; Railways, Railway Engineering; Materials of Engineering Construction; Mechanical Engineering; Electrical Engineering, Mechanical Engineering; Mining Engineering, Metallurgy; Naval Architecture and Marine Engineering; Miscellaneous, including Military Engineering, Aeronautical Engineering, and Heating and Ventilation.

The Congress will be opened at 10 A.M. on Monday, September 20, in the new Auditorium Building, where the subsequent sessions will be held. At the opening session there will be addresses of welcome and responses, an address by General George W. Goethals, Honorary President, and the presentation of the John Fritz Medal to Dr. James Douglass. Below is presented the complete program of the Congress.

## PROGRAM OF THE INTERNATIONAL ENGINEERING CONGRESS, 1915

San Francisco, California, September 20-25

*All sessions are to be held in the Auditorium Building, Civic Centre, Hayes and Larkin Streets, at Market Street.*

Opening General Session.

*Monday, Sept. 20, 10 a.m.*

Address of welcome by the Mayor of San Francisco.

Addresses by General Goethals, Honorary President of the Congress, by Vice Presidents and by distinguished delegates.

Presentation of John Fritz Medal to Dr. James Douglas.

### THE PANAMA CANAL

General Session.

*Monday, Sept. 20, 2 p.m.*

Introductory Chapter, General G. W. Goethals.

Commercial and Trade Aspects of the Panama Canal, Emory R. Johnson.

The Working Force of the Panama Canal, Captain R. E. Wood.

Purchase of Supplies for the Panama Canal, F. C. Boggs.

Outline of Canal Zone Geology, Donald F. MacDonald.

Climatology and Hydrology of the Panama Canal, F. D. Willson.

### WATERWAYS

Session 1.

*Tuesday, Sept. 21, 10 a.m.*

The Province of Waterways in the Internal Commerce and Development of a Country, Brigadier-General W. H. Bixby, U. S. A.

Artificial Waterways and Natural Channels and Bodies of Water linked by Artificial Channels, constituting Inside Routes, C. S. Riche.

The Waterway from the German Rhine through the Netherlands to the North Sea along the Rivers Rhine, Waal and Nieuwe Mass, C. A. Jolles.

Natural Waterways in the United States, Lieut.-Col. Wm. W. Harts.

Session 2.

*Tuesday, Sept. 21, 2 p.m.*

Flood Control, H. M. Chittenden.

Flood Control in China, Charles Davis Jameson.

Works for the Improvement of Navigable Estuaries, Prof. Dr. Luigi Luiggi.

The River Improvement Works in Japan, Tadao Okino.

Session 3.

*Wednesday, Sept. 22, 10 a.m.*

Dry Excavation, General G. W. Goethals.

Dredging in the Panama Canal, W. G. Comber.

Construction of Gatun Locks, Dam and Spillway, Brig. General W. L. Sibert.

Method of Construction of the Locks, Dams and Regulating Works in the Pacific Division of the Panama Canal, S. B. Williamson.

SESSION 4.

*Wednesday, Sept. 22, 2 p.m.*

Lock Gates, Chain Fenders and Lock Entrance Caissons, Henry Goldmark.

Emergency Dams above Locks of the Panama Canal, T. B. Monniche.

Design of the Lock Walls and Valves of the Panama Canal, L. D. Cornish.

SESSION 5.

*Thursday, Sept. 23, 10 a.m.*

The General Design of the Locks, Dams and Regulating Works of the Panama Canal, Brig. General H. F. Hodges.

The Design of the Spillways of the Panama Canal, E. C. Sherman.

Hydraulics of the Locking Operations of the Panama Canal, R. H. Whitehead.

IRRIGATION

SESSION 6.

*Thursday, Sept. 23, 2 p.m.*

Irrigation Enterprise in the United States, C. E. Grunsky.

Economic Advisability of Irrigation, F. H. Newell.

Distribution Systems, Methods and Appliances in Irrigation, J. S. Dennis, H. B. Muckleston and R. S. Stockton.

Italian Irrigation, Prof. Luigi Luiggi.

Irrigation in Lybia (Italian Colony), Prof. Luigi Luiggi.

SESSION 7.

*Friday, Sept. 24, 10 a.m.*

Utilization of Underground Waters, G. E. P. Smith.

Irrigation in India, M. Nethersole.

Dams, Arthur P. Davis, D. C. Henny.

Earthen Dams, William Lumisden Strange.

SESSION 8.

*Friday, Sept. 24, 2 p.m.*

The Distribution of Water in Irrigation in Australia. Elwood Mead.

The Co-relation between Annual Demand and Supply from Natural Flow, with a Study of the Amount of Storage Necessary, L. C. Hill.

Irrigation in Spain,Distribution Systems, Methods and Appliances, J. C. Stevens.

Irrigation in Spain, Regulations Controlling the Use of Water, Metering Water for Irrigation and Methods of Charging, J. C. Stevens.

SESSION 9.

*Saturday, Sept. 25, 10 a.m.*

The Problem of Irrigation in the Argentine Republic, Carlos Wauters.

Duty of Water in Irrigation, Samuel Fortier.

Drainage as a Correlative of Irrigation, C. G. Elliott.

MUNICIPAL ENGINEERING

SESSION 1.

*Tuesday, Sept. 21, 2 p.m.*

City Planning, Nelson P. Lewis.

London Traffic in 1913, Sir Albert Stanley.

Transit Problem in American Cities, W. F. Reeves.

SESSION 2.

*Wednesday, Sept. 22, 10 a.m.*

Recent Progress and Tendencies in Municipal Water Supply in the U. S., J. W. Alford.

Municipal Water Supply in France, Belgium, Algeria-Tunisia, Dr. E. Imbeaux.

The Disposal of Suspended Matters in Sewage, Rudolph Hering.

Sewage for Low Countries with Special Regard to the Town of Amsterdam, A. W. Bos.

SESSION 3.

*Wednesday, Sept. 22, 2 p.m.*

Streets, George W. Tillson.

Rural Highways, L. W. Page.

Rural Highways, L. Limasset.

Construction and Maintenance of Rural Highways, Alfred Dryland.

Rural Highways, Arthur Gladwell.

The Struggle Against Dust, C. C. Dassen.

SESSION 4.

*Friday, Sept. 24, 10 a.m.*

Utilities, Dr. A. C. Humphreys.

Short Paper on Public Utilities, Edward Willis.

Arch Bridges of Hooped Cast Iron, Dr. Ing. Fritz von Emperger.

SESSION 5.

*Friday, Sept. 24, 2 p.m.*

Preliminary Municipal Engineering at Panama, Henry Welles Durham.

Municipal Engineering and Domestic Water Supply in the Canal Zone, George M. Wells.

Sanitation in the Panama Canal Zone, Charles F. Mason.

"Soliditit" Concrete Roads in Italy, Prof. Luigi Luiggi.

RAILWAY ENGINEERING

SESSION 1.

*Tuesday, Sept. 21, 10 a.m.*

The Status of the Railways of North and South America. F. Lavis.

Italian Railways, Prof. Luigi Luiggi.

The Status of Indian Railways, Victor Bayley.

The Status of Chinese Railways, Charles Davis Jameson.

The Status of Russian Railways, V. A. Nagrodsky.

The Status of Railways and Tramways in the Netherland East Indies, E. P. Wellenstein.

SESSION 2.

*Tuesday, Sept. 21, 2 p.m.*

Economic Considerations Controlling and Governing the Building of New Lines, John F. Stevens.

The Locating of a New Line, William Hood.

The Reconstruction of the Panama Railroad, Frederick Mears.

The Locating of a New Line, David Wilson.

Railway Construction Methods and Equipment in Australia, Maurice E. Kernot.

SESSION 3.

*Thursday, Sept. 23, 10 a.m.*

American Railroad Bridges, J. E. Greiner.

Tunnels, Charles S. Churchill.

Tunnels in Italy, Prof. Luigi Luiggi.

Tunnels in Switzerland, R. Winkler.

Track and Roadbed, George H. Pegram.

Session 4.

*Thursday, Sept. 23, 2 p.m.*

Recent Locomotive Development, George R. Henderson.
Rolling Stock (other than Motive Power), A. Stucki.
The Floating Equipment of a Railroad, F. L. DuBosque.
Railroad Terminals, B. F. Cresson, Jr.

Session 5.

*Friday, Sept. 24, 10 a.m.*

Electric Motive Power in the Operation of Railroads, William Hood.
Electric Motive Power in the Operation of Railroads, E. H. McHenry.
Signals and Interlocking, Charles Hansel.

### MATERIALS OF ENGINEERING CONSTRUCTION

Session 1.

*Tuesday, Sept. 21, 10 a.m.*

Structural Timber in the United States, H. S. Betts, W. B. Greeley.
Timber in Canada, R. H. Campbell.
Indian Timbers used in Engineering Construction, R. S. Pearson.
Timber in Russia, Mr. Tkachenko.
Preservative Treatment of Timber, Howard F. Weiss, Clyde H. Teesdale.

Session 2.

*Tuesday, Sept. 21, 2 p.m.*

Clay Products as an Engineering Material, A. V. Bleininger.
Aggregates for Concrete, S. E. Thompson.
Probable and Presumptive Life of Concrete Structure made from Modern Cements, Bertram Blount.
Volume Changes in Concrete, Alfred H. White.
Use of Wood and Concrete in Structures standing in Sea Water, with Special Reference to Dock Work, Harrison S. Taft.

Session 3.

*Wednesday, Sept. 22, 10 a.m.*

The Outlook for Iron, Prof. James Furman Kemp.
Alloy Steels in Bridgework, J. A. L. Waddell.

Session 4.

*Thursday, Sept. 23, 10 a.m.*

The Economics of the World's Supply of Copper, Thomas T. Read.
Consumption of Copper and its various Uses, Thomas T. Read, H. D. Hawks.
Alloys and their Use in Engineering Construction, W. Reuben Webster.
The Engineering Uses of Aluminum, Prof. Jos. W. Richards.

Session 5.

*Thursday, Sept. 23, 2 p.m.*

Testing of Materials, R. G. Batson.
Testing Full Size Members, Gaetano Lanza.
Proof Testing of Structures, J. E. Howard.

### MECHANICAL ENGINEERING

Session 1.

*Tuesday, Sept. 21, 10 a.m.*

Recent Advances and Improvements in Founding, Thomas D. West (deceased).
Forgings from the Early Times until the Present, C. von Philip.
Recent Progress and Present Status of the Art of Forging with Special Reference to the Use of Quick-Acting Forging Presses, A. J. Capron.
Permanent Shops, Pacific Terminals, Panama Canal, H. D. Hinman, A. L. Bell.

Session 2.

*Tuesday, Sept. 21, 2 p.m.*

Machine Shop Equipment, Methods and Processes, E. R. Norris.
Machine Shop Equipment, Methods and Processes, H. F. L. Orcutt.
Automatics, R. E. Flanders.
High Temperature Flames in Metal Workings, H. R. Swartley, Jr.

Session 3.

*Wednesday, Sept. 22, 10 a.m.*

The Gas Power System. A Survey of its Status in the Year 1915, Professor Charles Edward Lucke.
The Development of the Construction of Turbines in the Netherlands, D. Dresden.
The 1915 Steam Turbine, E. A. Forsberg.
The Diesel Engine in America, Max Rotter.

Session 4.

*Thursday, Sept. 23, 2 p.m.*

Developments in Modern Water Turbine Practice, Dr. H. Zoelly.
Water Wheels of Pressure Type, Arnold Pfau.
Hydraulic Power Development and Use, J. D. Galloway.
Water Wheels of Impulse Type, W. A. Doble.
Canadian Hydraulic Power Development, Charles H. Mitchell.

Session 5.

*Friday, Sept. 24, 10 a.m.*

Safety Engineering, Frederick Remsen Hutton.
Motor Vehicles, Passenger Type, Ethelbert Favary.
Motor Vehicles, Utility Type, A. J. Slade.
Motor Tractors, F. S. Davis.

Session 6.

*Friday, Sept. 24, 2 p.m.*

The Boiler of 1915, Arthur D. Pratt.
Compressed Air in the Arts and Industries, W. L. Saunders.
Equipment, Processes and Methods for Boiler Shop, E. C. Meier.

### ELECTRICAL ENGINEERING

Session 1.

*Wednesday, Sept. 22, 2 p.m.*

Economics of Electric Power Station Design, H. F. Parshall.
The Water Power of Sweden, Sven Lubeck.
Electric Power in Canadian Industry, Charles H. Mitchell.
The Effect of Hydro-Electric Power Transmission upon Economic and Social Conditions, Frank G. Baum.

Session 2.

*Thursday, Sept. 23, 10 a.m.*

Electrical and Mechanical Installations of the Panama Canal, Edward Schildhauer.
Electric Welding, C. B. Auel.
The Application of Electricity to the Heating of Metals, F. L. Bishop.
The Electric Motor as an Economic Factor in Industrial Life, David B. Rushmore.

Session 3.

*Thursday, Sept. 23, 2 p.m.*

The Influence of the Electric Motor on Machine Tools, A. L. DeLeeuw.
Effects of Electrolysis on Engineering Structures, Albert F. Ganz.
The Mechanical Problem of the Electric Locomotive, G. M. Eaton.
On the Production of High Permeability in Iron, Ernest Wilson.

MINING ENGINEERING

Session 1.

*Tuesday, Sept. 21, 10 a.m.*

Economic and Social Influence of Mining, W. H. Shockley.
Valuation of Metal Mines and Prospects, T. A. Rickard.
The Valuation of Oil Lands and Properties, M. E. Lombardi.
Valuation of Coal Mines and Lands, R. V. Norris.
Valuation of Anthracite Mines, R. V. Norris.
Valuation of Coal Lands, Samuel A. Taylor.
Evaluating Coal Properties in Western Canada, R. W. Coulthard.
Valuation in France, E. Gruner.

Session 2.

*Wednesday, Sept. 22, 10 a.m.*

Functions and Work of Exploration and Development Companies, H. W. Turner.
European Mining Finance, J. L. Gallard.
The Financing of Mines in the United States, Lucius W. Mayer.

Session 3.

*Wednesday, Sept. 22, 2 p.m.*

Organization and Staff of Mining Companies, W. H. Shockley, R. E. Cranston.
Relations of Governments to Mining, Horace V. Winchell.
Mine Inspection, J. W. Paul.

METALLURGY

Session 1.

*Tuesday, Sept. 21, 2 p.m.*

Symposium on Iron and Steel, edited by Henry M. Howe.
Iron and Steel Castings, John Howe Hall.
Metallography and the Hardening of Steel, Albert Sauveur.
Case Hardening of Steel, F. Giolitti.
The Duplex Process of Steel Manufacture, F. F. Lines.
Methods of Preventing Piping in Steel Ingots, Emil Gathmann.

Session 2.

*Thursday, Sept. 23, 10 a.m.*

Symposium on Copper, edited by E. P. Mathewson.
Process in Copper Metallurgy, Thomas T. Read.
Advances in Copper Smelting, Frederick Laist.
Metallurgy of Copper in Japan, R. Kondo.
Copper Metallurgy of the Southwest, Dr. James Douglas.
Reduction Works. Copper Queen Consolidated Mining Company, Douglas, Arizona, Forest Rutherford.
Advances made in the Metallurgy of Copper, Globe District, Arizona, L. O. Howard.
Improvements in Design and Construction of Modern Copper Plants, Chas. H. Repath.

Session 3.

*Thursday, Sept. 23, 2 p.m.*

Symposium on Copper (Continued).
Leaching Copper Ores, W. L. Austin.
The Metallography of Copper, William Campbell.
Boronized Cast Copper, Dr. E. Weintraub.
Electrolytic Refined Copper, A. C. Clark.
The Development of Electrolytic Copper Refining, Lawrence Addicks.
Physical Properties of Copper, Carle R. Hayward.

Session 4.

*Friday, Sept. 24, 10 a.m.*

Symposium on Gold and Silver, edited by C. W. Merrill.
Coarse Crushing Plant; 1,000 tons capacity, G. O. Bradley.
Crushing and Grinding, L. D. Mills, M. H. Kuryla.
Solution of Gold and Silver including Classification, M. H. Kuryla.
Filtration or Separation of Metal Bearing Solution, L. D. Mills.
Precipitation, G. H. Clevenger.

Session 5.

*Friday, Sept. 24, 2 p.m.*

Symposium on the Metallurgy of Zinc, edited by Walter Renton Ingalls.
Some Main Points in the Economics of the Metallurgy of Zinc, Walter Renton Ingalls.
The Development of Zinc Smelting in the United States, George C. Stone.
The Smelting and Refining of Lead, Dr. H. O. Hofman.
Symposium on the Utilization of Fuels in Metallurgy, edited by C. H. Fulton.
Pulverized Coal in Reverberatory Furnaces, D. H. Browne.
Burning Pulverized Coal in Copper Reverberatories, E. P. Mathewson.
Gas Producer Development, Z. C. Kline.
Surface Combustion (What is it?), C. E. Lucke.
Ore Dressing, Robert H. Richards.

NAVAL ARCHITECTURE AND MARINE ENGINEERING

Session 1.

*Tuesday, Sept. 21, 10 a.m.*

Ship Calculation, Resistance and Propulsion, D. W. Taylor.
Ocean Freighters, Ernest H. Rigg.
Recent Developments in Japanese Shipbuilding, Dr. S. Terano.
Bulk Freight Vessels of the Great Lakes, Prof. Herbert C. Sadler.

Session 2.

*Wednesday, Sept. 22, 10 a.m.*

River, Lake, Bay and Sound Steamers of the United States, Andrew Fletcher.
Special Types of Cargo Steamers for the United Coast to Coast Trade through the Panama Canal, George W. Dickie.
The Development of the Sail Yacht, Steam Yacht and Motor Yacht in American Waters, William Gardner.
The Lightship, G. C. Cook.

Session 3.

*Wednesday, Sept. 22, 2 p.m.*

Warships of the First Line of Battle, Colonel E. Ferretti.
The Submarine, R. H. M. Robinson.
Present Condition of the Submarine, Max A. Laubeuf.
Modern Marine Gun Armament, H. F. Leary.
General Problem of Naval Warfare, D. W. Knox.

Session 4.

*Thursday, Sept. 23, 10 a.m.*

Marine Boilers and Boiler Room Equipment, Charles F. Bailey.
The Development of the Marine Steam Turbine, H. C. Dinger.

The Application of the Steam Turbine to Marine Propulsion, J. F. Metten.

Recent Developments in Marine Engineering in Japan, Dr. M. Tsutsumi.

Session 5.

*Thursday, Sept. 23, 10 a.m.*

Coaling Plants and Floating Cranes of the Panama Canal, F. H. Cooke.

Cargo Handling Methods and Appliances, H. McL. Harding.

Some Economic Fundamentals of Freight Handling, David B. Rushmore.

The Modern Trend in American Marine Terminals, Robt. H. Rogers.

Cargo Handling Methods and Appliances, James A. Jackson.

Session 6.

*Friday, Sept. 24, 10 a.m.*

Fuel Oil, E. H. Peabody.

The Application of Diesel or Heavy Oil Engines to Marine Propulsion, G. C. Davison.

The Diesel Motor Applied to Marine Purposes, C. Kloos.

Session 7.

*Friday, Sept. 24, 2 p.m.*

Terminal Works, Dry Docks and Wharves of the Panama Canal, H. H. Rousseau.

Aids to Navigation of the Panama Canal, W. F. Beyer.

American Graving Dock Practice, Leonard M. Cox.

Dry Docks recently built in Italy, Prof. Luigi Luiggi.

### MISCELLANEOUS

Session 1 (Aviation).

*Wednesday, Sept. 22, 10 a.m.*

Aeronautics, Dr. A. F. Zahm.

Arrival of the Aeroplane, A. E. Berriman.

A Discussion concerning the Theory of Sustentation and Expenditure of Power in Flight, F. W. Lanchester.

Principles and Theories of Aerodynamics, J. C. Hunsaker.

Session 2 (Refrigeration).

*Thursday, Sept. 23, 10 a.m.*

Refrigeration, J. F. Nickerson.

Refrigeration, Thor Andersson.

Refrigeration in France, L. Marchis.

Session 3 (Agricultural Engrg. and Engineering Education).

*Friday, Sept. 24, 10 a.m.*

Agriculture and the Engineer, J. B. Davidson.

Some Observations on the Extent and Value of Farm Power Equipment, Philip S. Rose.

Some Considerations Regarding Engineering Education in America, George F. Swain.

Technical Education for the Professions of Applied Science, Ira N. Hollis.

Session 4 (Heating and Ventilation).

*Friday, Sept. 24, 2 p.m.*

Introductory Paper, R. C. Carpenter.

Recent Developments in Heating and Ventilating Art, D. D. Kimball.

Vacuum, Vacuo-Vapor and Atmospheric Heating Systems, Jas. D. Hoffman.

Recent Developments in Ventilating Machinery, W. H. Carrier.

Closing General Session.

*Saturday, Sept. 25, 11.30 a.m.*

### MEETINGS OF OTHER SOCIETIES

The American Society of Civil Engineers, the American Institute of Mining Engineers, and the American Institute of Electrical Engineers will also hold September meetings in San Francisco in the week preceding the International Engineering Congress. The headquarters of these societies and their places of meeting are listed below:

| *Society* | *Headquarters* | *Meetings* | *Dates* |
|---|---|---|---|
| A. S. C. E. | St. Francis Hotel | at headquarters | Sept. 16-18 |
| A. I. M. E. | Hotel Bellevue | at headquarters | Sept. 16-18. |
| A. I. E. E. | St. Francis Hotel | Civil Center Auditorium | Sept. 16-17 |

The meeting of the American Society of Civil Engineers is the Forty-seventh Annual Convention of the Society. The program includes a welcoming address by President Charles D. Marx; a Panama Canal session; a reception, dinner and dance in the Old Faithful Inn on the grounds of the Panama-Pacific International Exposition, and excursions to Del Monte, Santa Cruz and San José. The Society, through its Secretary, Chas. Warren Hunt, has extended a cordial invitation to the membership of our Society to participate in these events.

### THE ENGINEERS' SPECIAL

In the July issue of The Journal reference was made to the "getting-together" arrangements for the engineers of the five national engineering societies that are to journey to San Francisco via the Engineers' special train on the New York Central, leaving New York 7.45 p.m., Thursday, September 9. A large party is scheduled for this train, the names of a considerable number of whom were listed in the July issue. Since that issue, several additional reservations have been made, and those among the membership who were not referred to in the previous list, are named below:

J. W. Upp
Henry Hess and Mrs. Hess
H. H. Barnes, Jr.
Gano Dunn
Emmett B. Carter and one
J. A. Seymour, Mrs. Seymour and Miss Seymour
William N. Best
Kenneth Seaver
E. L. Folsom and Mrs. Folsom
L. C. Marburg
Miss Kate Gleason.
H. M. Wilson and Mrs. Wilson
Charles Whiting Baker
S. Haar and party
Ralph E. Flanders
H. R. Cobleigh

### PANAMA-CALIFORNIA EXPOSITION

The Exposition now being held at San Diego, California, is within easy reach of those visiting the Pacific Coast. This Exposition is also in commemoration of

the opening of the Panama Canal, but its theme is the exploitation of the possibilities and opportunities of the various sections of this coast, from Alaska to Peru.

The Exposition is staged in Balboa Park, in the heart of the city of San Diego, and its exhibits are grouped in an educational and attractive manner in twelve buildings.

### PANAMA-PACIFIC INTERNATIONAL EXPOSITION

The interest of the visiting members will probably center in the Exposition and its many features of attraction. The points of particular interest to the members of the Society will be the Manufactures and Varied Interests Building; the Machinery Building; the Mines and Metallurgy Building, and the Education Building.

The great palace of Machinery is the largest on the Exposition site and is nearly a thousand feet in length. In this palace numerous groups comprising examples of steam generators and motors, internal combustion motors, hydraulic motors, and wood and metal working tools are shown.

The exhibits in the palace of Mines and Metallurgy deal with the natural mineral resources of the world, their conversion into metal and manufacture in raw materials and forms for the various industries.

Education is represented by examples including methods of vocational training and municipal training, in addition to general educational work of schools and universities.

The Manufactures and Varied Industries palace contains products of manufacture and manual skill from all nations of the world.

### EXCURSIONS

For the benefit of members visiting San Francisco for the September meeting and the Congress, the following excursions to important engineering activities in California have been arranged. Some of these will be made by automobile without expense, and others will be at the cost of a round trip ticket.

September 18: San Francisco High Pressure Fire System.
Portrero Gas Works Electric Station A, Pacific Gas & Electric Co.
Spring Valley Water Works.

September 19: Delta Lands of the Sacramento and San Joaquin Rivers.
Spring Valley Water Works.

September 17 to 18: Great Western Power Company's Hydroelectric development on the Feather River.
Gold dredging at Oroville.

September 18 to 19: Pacific Gas & Electric Co.'s Hydroelectric development at Lake Spaulding and Drum Power House.
North Star & Empire Mines at Grass Valley.

September 17 to 19: Oil fields at Coalinga.

### THE RETURN TRIP

Members of the party that go to San Francisco by the Engineers' Special have the privilege of returning by any one of several routes, which are given below. Rates for any of these routes will be gladly quoted by Mr. Harner, the New York Central Lines agent.

Via Southern Pacific or Western Pacific to Ogden and Salt Lake City, over the Rocky Mountains to Denver or Cheyenne, thence via Chicago or St. Louis.

Via Los Angeles, San Pedro Route to Salt Lake City, and thence as above.

Via Los Angeles, the Santa Fé Route through Albuquerque (also to Denver if desired) to Chicago.

Via Los Angeles, El Paso and the Rock Island Route to Chicago.

Via Los Angeles and El Paso to New Orleans, thence via St. Louis, Chicago or Cincinnati.

Via Portland, Tacoma, or Seattle, thence via Ogden and Salt Lake City and the Rocky Mountains to Cheyenne or Denver, and Chicago or St. Louis.

Via Portland, Tacoma and Seattle to St. Paul, thence via Chicago.

Via Portland and Tacoma to Seattle, steamer or rail to Vancouver, thence via the Canadian Rockies, Winnipeg and St. Paul to Chicago.

## VOLUME 36 OF TRANSACTIONS

The annual volume of Transactions for 1914 has been distributed to the membership during the past month. This volume, like the previous ones, contains the papers and discussion given at the Annual and Spring meetings, in this case the Spring meeting at St. Paul-Minneapolis, together with reports of committees.

At the St. Paul-Minneapolis meeting there was given besides the miscellaneous papers, the symposium on powdered fuel, which is included in the volume; and among the miscellaneous papers were three contributed by local engineers on coal handling methods on the Great Lakes, flour milling and the hydraulic power development on the Mississippi River.

At the annual meeting there was a symposium on Locomotives of To-day, covering features of design and the results of operation of modern locomotives. There was also an all day meeting under the direction of the Public Relations Committee at which nine papers were presented on the general topic of the engineer in public service.

It is noteworthy that of the 45 papers and reports included in the volume, no less than 23 were prepared through the efforts of committees of experts in their respective fields, by which the authoritative character of the contributions is appreciably enhanced. There are 145 individual contributors, besides those who collaborated in the preparation of the several reports.

It was possible to include in this number of Transactions the report of the Boiler Code Committee in its

revised form, an early draft of which was sent to each member last November. This report is the most extensive, and will probably be the most far-reaching in its results, of any single undertaking by the Society up to the present time. Four states and one city have already adopted its provisions.

The variety of the papers presented and the wide scope of their contents is indicated by the following classified list of topics which were covered by the papers and discussion at the Annual and Spring meetings for 1914 and which are included in this volume:

SUBJECT CLASSIFICATIONS

Abrasives.
Air compressor unloaders.
Appraisals.
Ash fusion temperatures.
Biography.
Bonus payments.
Cast iron pipes.
Cement kilns.
Clinkering of coal.
Coal classification.
Crane wheels.
Damage cases.
Dams.
Economic problems.
Efficiency.
Electric drives.
Electric lighting plants.
Engineering training.
Ethics.
Factory buildings.
Feed water heaters.
Filters.
Fireproof construction.
Flanged fittings.
Floors.
Flour milling.
Friction losses.
Fuel.
Furnaces.
Fusion temperatures.
Gear testing machines.
Grinding wheels.
Hardening steel.
Heating boilers.
Heating value of fuels.
Hooke's joint.
Hydroelectric development.
Industrial service work.
Ingots.
Locomotives.
Materials of construction.
Meetings.
Methane.
Milling machines.
Municipal engineering.
Natural gas.
Necrology.
Police arm.
Powdered fuel.
Power plant auxiliaries.
Publicity.
Railroad equipment.
Railroad scales.
Recorders.
Reinforced concrete.
Sewage disposal.
Snow removal.
Society affairs.
Specifications.
Standardization.
Steam boilers.
Steel rails.
Stokers.
Storage of fuel.
Superheaters.
Symbols.
Testing meters.
Time studies.
Tool steel.
Transportation of fuel.
Universal joint.
Water meters.
Water power.
Weighing scales.

## THE USE OF MEMBERSHIP CARDS

The membership is warned to be on guard against persons representing themselves as members of the Society. Complaints continue to be received that men posing as members are attempting to borrow money.

Membership requirements were never so strict as they are to-day, and you will protect the Society as well as yourself by requiring a stranger announcing himself a member to show the introductory card. Every member of the Society in good standing receives a card of introduction every year with the date clearly shown.

# APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON OCTOBER 10, 1915

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages would qualify them and not with regard to professional qualifications, i.e., the ages of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of grading are also posted.

*The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these condidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned.* All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received by October 10, 1915.

## NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ALMEIDA, MANUEL G. ROSADO, Sales Engr., De La Vergne Mch. Co., Merida, Yucatan, Mexico

BAKER, NORMAN L., Mech. Engr., By-Products Coke Corp., Chicago, Ill.

BAKER, WM. H., Asst. Genl. Supt., The Atlas Portland Cement Co., Hannibal, Mo.

BALOUGH, CHARLES, Cons. Engr., Springfield, Ohio

BARNES, WALTER E., Vice-Pres., Consolidated Engrg. Co., Boston, Mass.

BEAKEY, PATRICK J., Foreman Type Dept., Royal Typewriter Co., Inc., Hartford, Conn.

BEAUBIEN, JAMES A., Mech. Engr., Weber Subterranean Pump Co., New York, N. Y.

BERGMAN, CARL AXEL, Palmarito de Cauto, Oriente, Cuba

BLACK, ALEXANDER L., Engr. in charge of design and construction, New Orleans Office, Ford, Bacon & Davis, New Orleans, La.

BOYD, JAMES E., Prof. of Mechanics, Ohio State Univ., Columbus, Ohio

BOYLE, WM. GEO., Mech. Supt. & Engr., Estate of Henry W. Oliver, Pittsburgh, Pa.

BREWSTER, HENRY B., Engr., with H. S. Kerbaugh, Inc., New York, N. Y.

BRUNNER, GEO. L., Treas. & Genl. Mgr., Brunner Mfg. Co., Utica, N. Y.

BRYAN, ARTIS CHESTER, Chief Engr. & Factory Mgr., Lefever Arms Co., Syracuse, N. Y.

CHACE, ERNEST M., Wks. Mgr., The Cincinnati Milling Mch. Co., Cincinnati, Ohio

CHARLES, LA VERN JOHN, Civil Engr., Constr. Engr., U. S. Reclamation Service, Elephant Butte, New Mexico

CLARK, HENRY D., with Alloy Steel Spring Co., Jackson, Mich.

COLLISON, THOMAS A., Mech. Engr., Mt. Vernon Car Mfg. Co., Mt. Vernon, Ill.

CUNNINGHAM, GEORGE F., Owner, Cunningham Construction Co., Blissville, Ark.

DOYLE, EDMUND M., Mgr., Doyle Estate Co., San Francisco, Cal.

ELY, HAROLD F., Mech. Draftsman, Alberger Pump & Condenser Co., New York, N. Y.

ENGLERT, ALFRED, Mech. Engr., Lidgerwood Mfg. Co., New York, N. Y.

FITTS, EDWIN, Engr., Detroit Stoker Co., Detroit, Mich.

FORNEY, J. RAYMUND, Southern Rep., Ralston Steel Car Co. of Columbus; Baltimore, Md.

GHERARDI, BANCROFT, Engr. of Plant, American Telephone & Telegraph Co., New York, N. Y.

GINORIO, FRANCISCO R., Elec. Engr., Cuban-American Sugar Co., Central Delicias, Oriente, Cuba

GRANGER, ABBOTT DEAN, Pres., A. D. Granger Co., New York, N. Y.

GRAUTIER, LESLIE V., Dist. M.P. Insptr., Pittsburgh Dist. & Chicago Div., Baltimore & Ohio Railroad, Pittsburgh, Pa.

GUIGNARD, C. G., Columbia, S. C.

HADLEY, SAMUEL L., Asst. Dir. of Sales, Fairbanks, Morse & Co., Chicago, Ill.

HALL, ROLAND B., JR., Mgr. New York Office, Harrisburg Fdry. & Mch. Co., New York, N. Y.

HENDERSON, MALCOLM McG., Chief Mech. Engr., Australian Commonwealth Rwys., Melbourne, Australia.

HENNING, WARREN K., Sales Engr., Murphy Iron Works, Chicago, Ill.

HICKS, WM. A. B., Chief Draftsman, I. P. Morris Co., Philadelphia, Pa.

HITCHCOCK, HARRY S., Treas., Baker Iron Works, Los Angeles, Cal.

HOBART, HENRY M., Cons. Engr., General Elec. Co., Schenectady, N. Y.

HOWES, BENJAMIN A., Engineer in private practice, New York, N. Y.

HOXIE, V. W., Marine Dept., The Babcock & Wilcox Co., Pacific Coast Branch, San Francisco, Cal.

HUFF, RUSSELL, Cons. Engr., Packard Motor Car Co., Detroit, Mich.

JELLETT, STEWART A., Cons. and Constr. Engr., Philadelphia, Pa.

JOHNSON, GEORGE A., Mech. Supt., with W. H. Miner, Chicago, Ill.

JONES, HAROLD C., Asst. to Vice-Pres., Inland Steel Co., Chicago, Ill.

KLEIN, BERNARD J., Exhibit Mgr., The Bristol Co. of Waterbury, Conn., Palace of Machinery, San Francisco, Cal.

LANGILLE, HERBERT B., Asst. Prof. Mch. Design and Mech. Drawing, Univ. of Cal., Berkeley, Cal.

LARKIN, FRED V., Asst. Prof. Mech. Engrg., Lehigh Univ., So. Bethlehem, Pa.

LEHMAN, WERNER, Mech. Engr., Bucyrus Co., South Milwaukee, Wis.

LEWIS, E. J., Supt., Climax Mfg. Co., Corry, Pa.

LEWIS, GEORGE WM., Asst. Prof. Mech. Engrg. in charge of Exper. Engrg., Swarthmore College, Swarthmore, Pa.

LEWIS, WARREN B., Cons. Engr., Providence, R. I.

LICHTNER, WILLIAM O., Cons. Engr., Newton Highlands, Mass.

LOOSE, THERON L., Genl. Supt., Hendee Mfg. Co., Springfield, Mass.

LYSTER, T. L. B., Chief Engr., Hooker Electrochemical Co., Niagara Falls, N. Y.

MACLEOD, NORMAN MACCALLUM, Lab. Elec. Engr., Western Electric Co., New York, N. Y.

MAAS, ELOV F., Chief Draftsman Machinery Div., Navy Yard, Puget Sound, Wash.

MANCHESTER, HENRY C., Supt. of Motive Pwr. & Equip., Delaware, Lackawanna & Western R.R., Scranton, Pa.

MATHEY, HENRY C., Asst. Engr., Underwriters' Laboratories, Inc., New York, N. Y.

METTEN, JOHN F., Chief Engr., Wm. Cramp & Sons Ship & Eng. Bldg. Co., Philadelphia, Pa.

MORSS, HENRY A., Vice-Pres., Simplex Wire & Cable Co., also The Morss & Whyte Co., Boston, Mass.

NOBLE, HOWARD A., Vice-Pres., Pittsburgh Spring & Steel Co., Pittsburgh, Pa.

PACKER, E. RAY, Mech. Engr., The Q & C Co., Chicago, Ill.

PAFFEN, PAUL J., Engr., Barrett Mfg. Co., New York, N. Y.

PARCE, JOSEPH YALE, Director Shop Work, Manual Training High School, Denver, Colo.

PROUTT, FREDERICK G., Cons. Engr., Memphis, Tenn.

RUSS, JOHN B., Mech. Supvr., The Robert N. Bassett Co., Derby, Conn.

SANDERS, W. E., Mgr. Packing Dept., Essex Rubber Co., Trenton, N. J.

SHAW, WM. M., Vice-Pres. & Genl. Mgr., The Benj. F. Shaw Co., Wilmington, Del.

SMITH, ALBERT H., Production Engr., Sefton Mfg. Co., Chicago, Ill.

SMITH, JAMES C., Supt., McNab & Harlin Mfg. Co., Paterson, N. J.

STREIFF, ABRAHAM, Hyd. Engr., Fargo Engrg. Co., Jackson, Mich.

TOMPKINS, GEORGE R., Head of Mech. Dept., Wilberforce Univ., Wilberforce, Ohio

VOCKE, CHAS. WM., Developing patent claims, Ridgewood, N. J.

WAHL, HENRY R., Mech. Engr., Commonwealth Edison Co., Chicago, Ill.

WALKER, F. W., JR., Genl. Mgr., Beaver Falls Art Tile Co., Beaver Falls, Pa.

WATKINS, EDWARD G., In charge Engrg. Dept., Heywood Bros. & Wakefield Co., Gardner, Mass.

WHITE, HAROLD E., Controller Engr., Crocker-Wheeler Co., Ampere, N. J.

WILLIAMS, ARTHUR, Genl. Commercial Mgr., The New York Edison Co., New York, N. Y.

WOODARD, WM. E., Asst. Chief Engr., Amer. Loco. Co., Schenectady, N. Y.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ABBE, ROY H., Mech. Engr., Towle Mfg. Co., Newburyport, Mass.

ADAIR, CRAIG, Mech. Engr., The Baldt Steel Co., New Castle, Del.

Airey, John, Asst. Prof. of Engrg. Mechanics, Univ. of Mich., Ann Arbor, Mich.

Bronson, Carlos E., Asst. Mech. Engr., Kewanee Boiler Co., Kewanee, Ill.

Buckley, Ambrose T., Electrician, Dept. of Public Charities, Staten Island, N. Y.

Cobb, Howard P., Industrial Engr., D. B. Lewis & Co., Boston, Mass.

Curtiss, Charles B., with The Wickes Boiler Co., Saginaw, Mich.

Daniels, Clarence W., Plants Engr., Norton Co., Worcester, Mass.

French, Charles M., Sales Engr., Wagner Elec. Mfg. Co., Springfield, Mass.

Graves, Ralph I., Mech. Asst. to Genl. Pur. Agt., Chicago & North Western Rwy. Co., Chicago, Ill.

Grunert, Arthur E., Asst. Efficiency Engr., Commonwealth Edison Co., Chicago, Ill.

Hempel, Albert G., Denver, Colo.

Heyward, Theodore C., Asst. to Thomas B. Whitted, Charlotte, N. C.

Nourse, Chester Linwood, Mech. Engr., The Fiberloid Co., Indian Orchard, Mass.

Pew, Joseph N., Jr., Vice-Pres., Sun Co., Philadelphia, Pa.

Pullen, Royal R., Mech. Engr., The Canadian Klondyke Mining Co., Ltd., Dawson, Y. T., Canada

Reed, Harry A., Resident Engr., Stone & Webster Engrg. Corp., Boston, Mass.

Reeds, Clarence, Cons. Engr. with John A. Stevens, Lowell, Mass.

Sees, Joseph Frank, Asst. Chief, Equip. Engrg. Div., Union Metallic Cartridge Co., Bridgeport, Conn.

Thompson, Paul W., Tech. Engr., The Edison Ill. Co., Detroit, Mich.

Wing, Stephen R., Prof. Mech. & Elec. Engrg., Pennsylvania College, Gettysburg, Pa.

FOR CONSIDERATION AS JUNIOR

Blank, Bernard, Elec. Designer, Pennsylvania Railroad, West Jersey & Seashore Div., Camden, N. J.

Burley, E. R., Jr., Asst. Engr., Old Reliable Motor Truck Co., Chicago, Ill.

Dedicke, Carl E., Engr., The Felters Co., Inc., Middleville, N. Y.

Dickey, Ralph L., Planning Clerk, Warren Power Sta., N. Y., N. H. & H. R. R., Warren, R. I.

Endicott, George, with The Morgan Spring Co., Worcester, Mass.

Follmer, Clinton L., Mech. Engr., The Consolidation Coal Co., Inc., Fairmont, W. Va.

Franklin, Paul A., Supt. of Newark Warehouse, American Sanitary Wks., Harrison, N. J.

Guilford, Edward F., Asst. Supt. of Dial Dept., Hamilton Watch Co., Lancaster, Pa.

Howe, Jack L., Estimator & Salesman, Otis Elev. Co., San Francisco, Cal.

Hoyt, Frank W., Engr., Winchester Repeating Arms Co., New Haven, Conn.

Lauer, Carleton J., Tiffin, Ohio

MacKenzie, G. Earl, Research Dept., Western Elec. Co., New York, N. Y.

May, Howell B., Special Apprentice with American Steel Foundries, Alliance, Ohio

Neil, Edmund B., Personal Asst. to Chief Eng., Truck Dept., Pierce-Arrow Motor Car Co., Buffalo, N. Y.

Norris, J. Boyd, Jr., Oiler with The Coastwise Transportation Co., Boston, Mass.

Parsell, Roy Linwood, with Winchester Repeating Arms Co., New Haven, Conn.

Reynolds, James J., Genl. Supt., Thurlow Steel Works, Inc., Chester, Pa.

Schaefer, Walter A., Underwriter with Workmen's Compensation Insurance & Ocean Accident & Guar. Corp., Ltd., New York, N. Y.

Scrannage, Lawrence E., Asst. in Planning Dept., Remington Arms & Ammunition Co., Bridgeport, Conn.

Short, Frank, Instr. in Elec. Engrg., Univ. of Pennsylvania, Philadelphia, Pa.

Stark, Willet E., Engr., The B. F. Sturtevant Co., Hyde Park, Mass.

Strader, Roland Harold, Jr. Asst. to Supt., Standard Gas Light Co., New York, N. Y.

Sturmfelsz, George J., Jr., Draftsman, Maryland Steel Co., Sparrows Point, Md.

Voorhees, Albert C., Head of Tech. Dept., Lake Torpedo Boat Co., West Coast Branch, Long Beach, Cal.

Weiss, Herbert A., Asst. Prof. in Drawing, Georgia School of Tech., Atlanta, Ga.

Wilton, Hugh, Dir. of Mch. Shop Practice & Trade, State Trade School, Putnam, Conn.

## APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE

Bass, W. J., Willard J., Engr., Armour & Co., Chicago, Ill.

Thompson, O. C., Mech. Engr., Wirebounds Corp., Chicago, Ill.

PROMOTION FROM ASSOCIATE-MEMBER

Misostow, Henry, Mech. Engr., Smoke Dept., City of Chicago, Chicago, Ill.

Wright, Paul, with American Cast Iron Pipe Co., Birmingham, Ala.

PROMOTION FROM JUNIOR

Blumenfeld, Ralph, Asst. Mech. Engr., Keller Mech. Engr. Co., Brooklyn, N. Y.

Braman, Samuel N., with The Morss & Whyte Co., Boston, Mass.

Carter, Harold T., Supt., Lucknow Water Works, Lucknow, India

Woods, Samuel H., Asst. Engr., Elec. Div., General Vehicle Co., Inc., Long Island City, N. Y.

## SUMMARY

| | |
|---|---|
| New Applications | 124 |
| Applications for change of grading: | |
| Promotion from Associate | 2 |
| Promotion from Associate-Member | 2 |
| Promotion from Junior | 4 |
| | 132 |

## NEW APPLICATIONS FOR LISTING IN THE 1916 YEAR BOOK

Applications should be filed by September 27, in order that those elected may qualify in time to be included in the list of members appearing in the 1916 issue of the year book.

# THE CONNORS CREEK PLANT OF THE DETROIT EDISON COMPANY

BY C. F. HIRSHFELD, DETROIT, MICH.

Member of the Society

THE phenomenal growth of Detroit's population and industries has been widely heralded, but it is probable that the extent of this growth and its significance to the central station industry is not appreciated by those not closely in touch therewith. For this reason the curves in Fig. 1 are shown. The upper curve, showing the variation of population during the past decade, is probably approximately correct, because it fits smoothly into the curve obtained by plotting United States Census figures and because it checks very closely with the more accurate of the estimates which have been made from time to time. This curve indicates that the population of Detroit in 1914 was about 1.6 times as great as it was in 1904, just ten years before.

The annual output of the central stations, as given by the next lower full-line curve, has increased much more rapidly than the population. In the year 1914 it was about 21.4 times as great as in 1904. The fact that the maximum annual peak was only ten times as great in 1914 as in 1904 indicates that a very large part of the increased annual output was due to increased industrial application. This is also partly indicated by the curve showing variation of load factor.

A map of the City of Detroit is given in Fig. 2. The heavy full lines radiating, roughly, from a point near the bottom center of the figure indicate radial streets upon which the principal car lines are operated. These naturally determine the directions of growth and they indicate that, other things equal, Detroit's area may be expected to preserve a roughly semicircular shape as it expands. The heavy dotted lines indicate the rights of way of the various steam railroads entering the city. Other things equal, these rights of way, combined with the river frontage, indicate the probable future locations of the larger manufacturing industries. Apparently, these industries may be expected to scatter all along these lines in the future, as they have in the past.

The small rectangular spots indicate the locations of the various substations of the Detroit Edison Company. These are so drawn that the length of a side indicates the relative capacity. The concentration near the center from which the radial streets diverge is due to the fact that this is the business center of the city and that it is served with direct current. This gives a very concentrated and very important direct current load at this point.

The two circular spots near the lower left hand corner of the figure indicate the location of Delray power houses No. 1 and No. 2. These have an aggregate maximum capacity of about 95,000 kw. and contained practically all the generating equipment of the company before the Connors Creek plant was built. They are adjacent to one another and operated as one plant.

When it became evident about 1912 that greatly increased capacity would soon be required, two possible solutions were available; a third power house could have been built at the Delray site or a new site could have been selected. Consideration of the direction of growth of the city; the rapidly increasing population and industrial development of the east side; the location of the heavy direct current load; necessity for continuity of service with an ever increasing complexity of distribution system fed from one point near what might be called a corner of the city; and numerous similar items resulted in the choice of a new site, despite the many duplications which such a choice involved. The transmission loss in underground cables of a mean length of seven miles required to serve the growing east side manufacturing district and the fixed charges on these cables and their conduits were, by themselves, almost adequate to determine the choice.

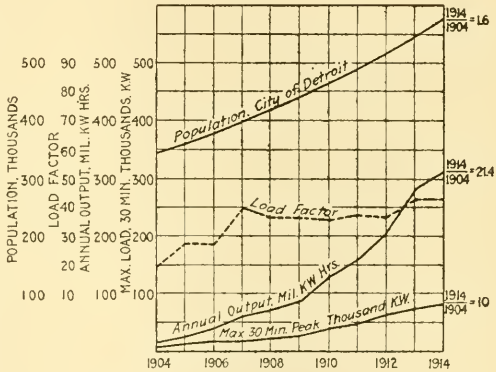


FIG. 1 CURVES INDICATING GROWTH OF CITY AND LOAD

The site chosen is indicated by the circular dot near the lower right hand corner of Fig. 2. Being on the river front, excellent condensing water is available in enormous quantities. In this respect, it is even better situated than the older site at Delray, as the river flows from the newer toward the older site and picks up all the sewage of the city while passing the water front. Being at the river end of a terminal railroad, the new site can be supplied with coal as easily as the old site, and if water transportation of coal should become profitable, both sites are equally well located to avail thereof.

Considering the distribution problems, the new site may be said to be strategically located as a combination with the older site at Delray. A glance at the map and a study of the radiating streets and of the railroads, will show this very clearly.

The Connors Creek site is large enough to accommodate two power houses, each with greater capacity than that of the two power houses at Delray combined. The first house was planned to accommodate six 25,000 k.v.a. units, but it seems probable that this unit size will be increased before the last

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units are installed. The plan of this house is shown in Fig. 3, together with the canals and tracks which serve it. The river is located beyond the left-hand side of the figure and runs in a direction roughly parallel to the left-hand end of the plate, and upward. The diagonal position of the plant was dictated by the shape of the site, the necessity of leaving room for a future power house, the curves required for railroad tracks, and the location of the river which determined the direction and location of the canals. One-third of the first power house on the Connors Creek site has been built and two of the proposed six units are installed. The building is closed with a temporary end, so that the machinery now installed can be operated until and while future extensions are being constructed. The intake and overflow canals are completed in full size for six units.

An architect's drawing of the finished power house is given in Fig. 4 and a sectional elevation in Fig. 5. The latter shows the construction to best advantage and should be consulted in connection with the description which follows.

The coal enters the train shed in drop-bottom cars (usually of the 50-ton size) which move on the lower group of tracks shown in Fig. 3 after being weighed on the railway scales indicated near the upper left-hand corner of that figure. The cars dump into hoppers under the tracks in the train or coal shed, there being one hopper for each unit of one turbine and two boilers. A motor-driven, variable-speed, flight conveyor with a capacity of 120 tons per hour, receives the coal from the hopper, carries it up a rather sharp incline and discharges it into a four-roll motor-driven crusher of similar capacity. This crusher breaks from 18-in. cubes, or smaller, to 100 per cent through a $1\frac{3}{4}$-in. ring.

The crusher discharges directly into a motor-driven, constant-speed, lapping bucket conveyor with 30 by 36 in. buckets. This conveyor forms an endless chain which entirely encloses the section of the boiler house, as indicated in Fig. 5. It carries the coal up on the side nearest the coal shed and discharges it into any one of the three coal bunkers which serve the two boilers of one unit. The hopper, pan conveyors, crusher and bucket conveyor for each unit of one turbine and two boilers are so located that they can deliver through chutes to one adjacent range of bunkers, serving thus as a spare for that range.

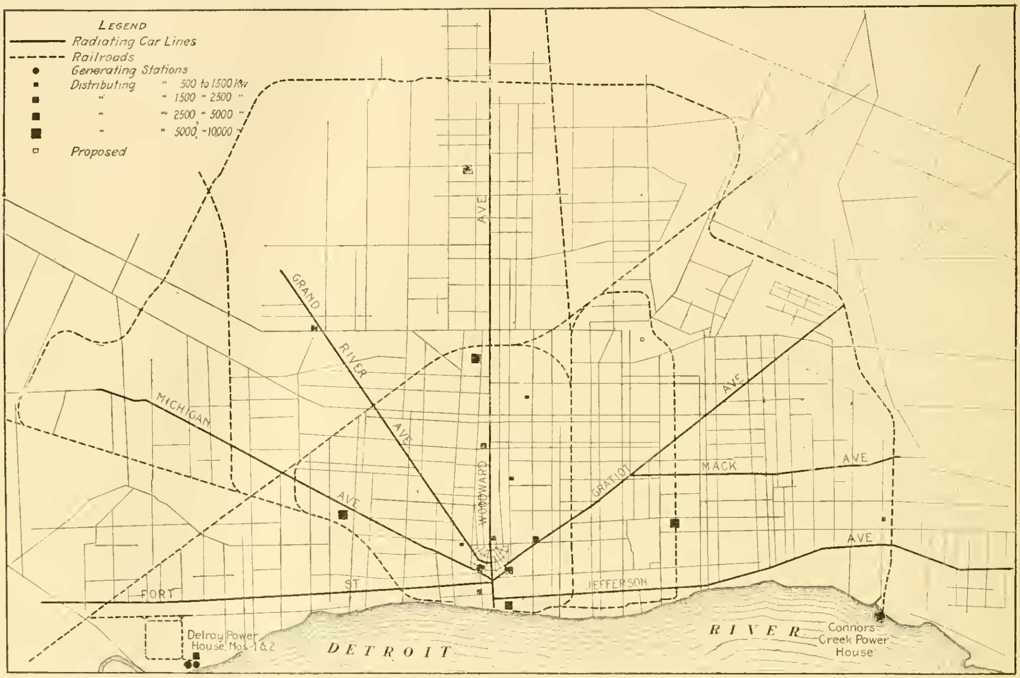


Fig. 2 Map of the City of Detroit showing Location of Plants

The entire coal handling equipment is electrically operated and the control is centralized at a board in the coal crushing room. Starting devices are electrically interlocked so that the various pieces of apparatus must start in proper sequence. Provision is also made to prevent starting until an observer on the floor above the coal bunkers has determined that the exposed upper horizontal run of the bucket conveyor is clear, and has so indicated. Emergency buttons are provided at numerous points along the run of the bucket conveyor; pushing any one of these stops the entire system and it cannot be started again until that particular emergency button has been reset by means of a key. The custodian of this key is therefore the only individual who can start the system after an emergency stop, and even then he must go to the point from which the stop was made.

After the coal has been dropped into the bunkers, it de-

scends by gravity to the stokers. The latter are of the underfeed, sloping fire-bed variety and there are twenty-six retorts per boiler. These are arranged in two groups of thirteen each, the boiler being fired from the two ends, as shown in Fig. 6. Ash and clinkers are removed by two clinker grinder bars located in a sort of pit running across the center of the furnace and are discharged into the ash hopper. This is an enclosure within the wind box or plenum chamber below the boiler and holds the refuse until it is finally dropped directly

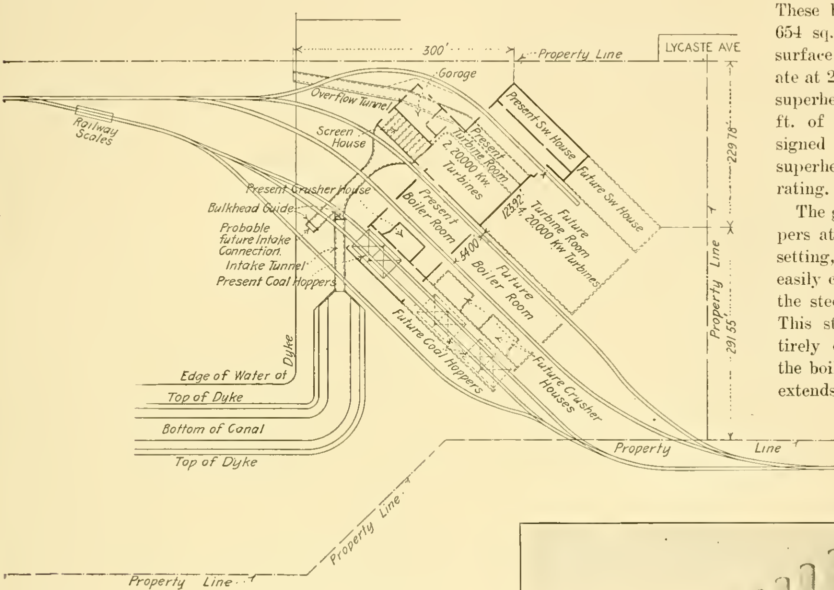


Fig. 3 Plan of Site of the New Power House

into standard railroad cars which run lengthwise of the house directly under the ash hoppers.

The stokers are driven through chains by direct current motors, the speed of which can be varied from 200 to 2000 r.p.m. This wide range of speed is obtained by means of armature throw over from 125 to 250 volts combined with field control. The motors are handled by means of drum controllers located at the gauge board of the particular boiler which they serve and electric tachometers are used to indicate stoker speeds at this board.

Motor driven blowers supply the air required for combustion. There are three of these blowers per range of two boilers. One of the three serves as a spare and is located between the two boilers. It is arranged to discharge either way through a Y-shaped duct. All of the blowers discharge through expanding ducts which are designed to recover the greatest possible fraction of the velocity head. These large ducts lead into a plenum chamber with a horizontal section equal to the horizontal section of the furnace. The stoker wind boxes form part of the roof of this chamber, so that the air passes directly from the plenum chamber to the stoker and does not have to pass through small ducts of any kind. Each blower is designed to deliver at maximum 74,000 cu. ft. of air per minute against a static pressure of 6.5 in. of water pressure. The motors are shunt wound and are direct connected to the blowers through flexible couplings. Their speed can be varied from 300 to 750 r.p.m. The drum type controllers are mounted at the gauge boards of the boilers served, directly under gauges which indicate the static pressure in the plenum chamber.

The boilers are similar to those used in the older plant at Delray, but are set 3 ft. higher so that the height of the combustion chamber is 33 ft. These boilers each have 23,654 sq. ft. of water heating surface and are built to operate at 225 lb. per sq. in. The superheaters have about 2400 ft. of surface and are designed to give 200 deg. fahr. superheat at 200 per cent of rating.

The gases, leaving the dampers at the top of the boiler setting, pass upward through easily curved breechings, into the steel stack near its base. This stack is supported entirely on the steel work of the boiler room structure and extends to a height of 325 ft. above the floor on which the stokers are located. It has a height of about

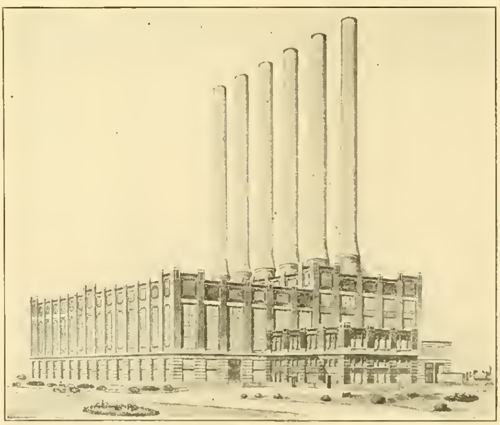

Fig. 4 View of the Projected Connors Creek Power House

240 ft. above the roof of the boiler house. The stack is brick lined and has a diameter of 16 ft. inside the lining.

As already mentioned, there are only two boilers per turbine. When operating the turbine at full load, the boilers will operate at about 170 per cent of Centennial rating. In the ordinary sense, there are no spare boilers. Experience has shown, however, that these boilers can be safely and

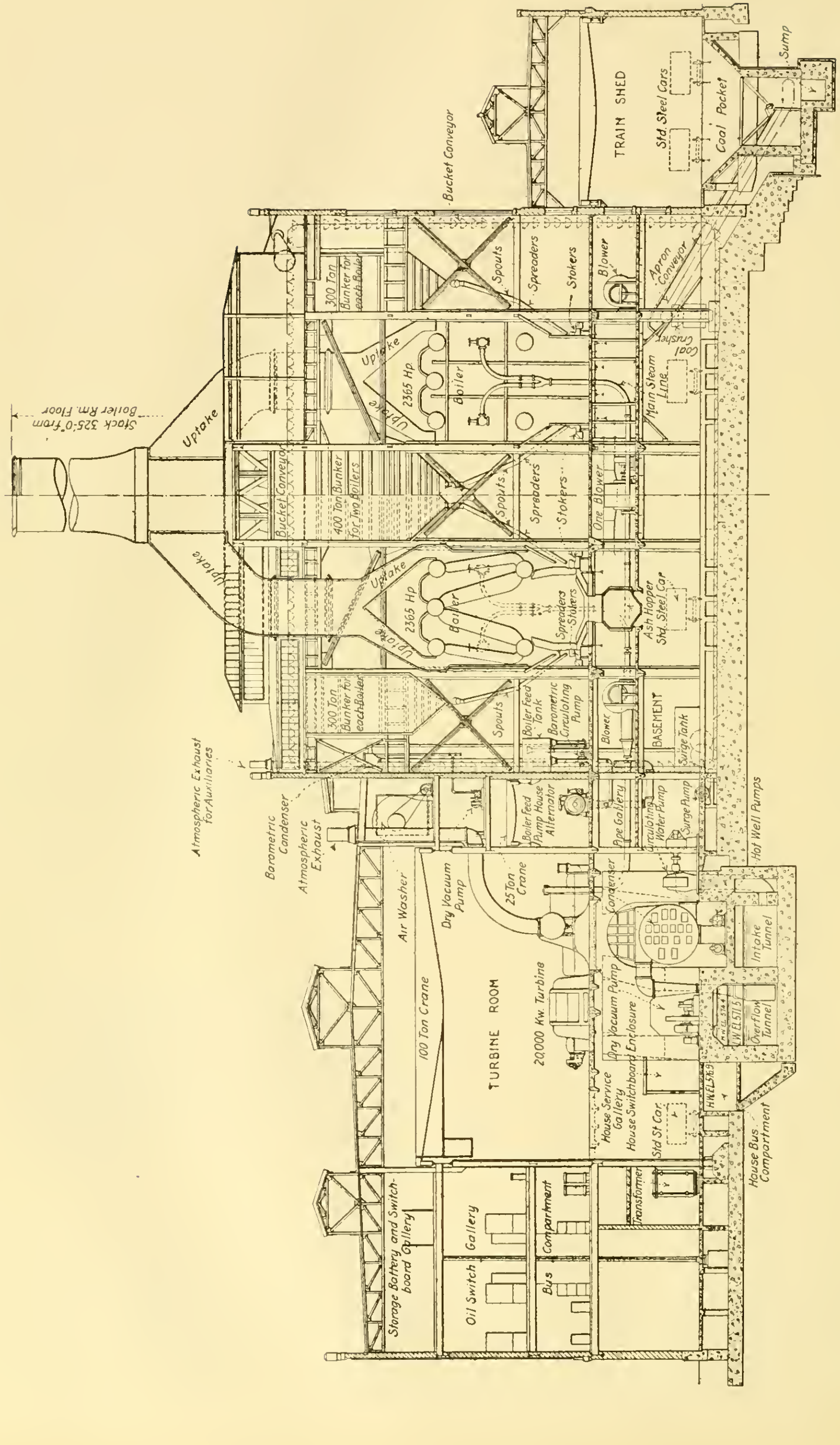


Fig. 5 Cross-Section of the New Connors Creek Power House showing Arrangement of Apparatus

economically operated at ratings considerably in excess of 170 per cent and provision has been made to enable three boilers to supply steam to two turbine units. When carrying full turbine loading under these conditions, each of the three boilers will have to operate at about 225 per cent of rating.

The main live steam piping consists of a run from two boilers to the unit which they serve, all of these runs being cross connected by a cross-over header. All of this piping is located in the so-called pipe gallery below the stoker floor, except, of course, the leads dropping down from the boilers and rising to the turbine throttles.

The steam leads from each boiler are of 10 in. pipe and these join together in a Y-fitting, which has a 14 in. discharge. Under full load conditions with two boilers supplying one unit, the steam velocities will be about 10,500 ft. per min. in the 10 in. pipe and 12,000 ft. per min. in the 14 in. pipe. With three boilers supplying two units, these velocities will rise to about 14,000 and 16,000 ft. per min., respectively.

The proposed use of the cross-over main necessitated a design which should permit steam from any two boilers to flow into that main, and steam from the main to flow into any turbine lead, with practically equal facility. After many designs had been considered, that shown in Fig. 7 was adopted. The steam leaving the 10 x 14 x 10 in. Y-branch previously mentioned, passes through a cast steel expanding nozzle which enlarges to a diameter of 28 inches. This, in turn, leads into a 28 in. cast steel side-outlet T or side-outlet cross. The 28 in. lateral outlets of the latter fittings are the connection points of the cross-over main. The velocity of the steam passing into the cross-over, or from the cross-over main to the turbine lead, is thus reduced to about one-quarter of its value in the 14 in. pipes, or roughly, a little less than 4000 ft. per min. under the worst conditions. The steam turns through the necessary right angle at this low velocity and therefore with small loss.

Steam leaving the 28 in. fitting on its way to the turbine is carried through a tapered reducer with a discharge diameter of 14 in. Similarly, steam leaving the 28 in. fitting on its way to the cross-over main passes through a tapered reducer which is cast with its longitudinal axis in the shape of a quarter circle. This reducer leads the steam into a 14 in. return bend, as shown in Fig. 7.

The steam for the auxiliary turbines, which will be mentioned later, is taken from a six inch outlet on top of the 28 in. fittings above described.

All superheated steam piping is full weight steel with welded flanges. The flanges are finished smooth and corrugated steel gaskets are used. All fittings are cast steel. At the Delray plant, Hopkinson-Ferranti valves with Venturi throats were used; these have been found to cause an excessive pressure drop because of the short length of the expanding nozzle and were therefore not deemed desirable for the new plant if an equally reliable, full opening form could be found. Full throated gate valves made by Hopkinson of the same material as the Ferranti valves were therefore used in the Connors Creek plant.

The atmospheric exhaust from the main unit is made of riveted steel pipe and fittings. The auxiliary exhaust piping is lap welded steel with Van Stone joints and fitted with corrugated copper gaskets. All valves in the exhaust lines are steel gate valves of American make. All saturated steam piping is extra heavy steel fitted with steel flanges. The fittings are all cast steel and steel valves of American make are used.

The feed water piping is extra heavy, lap welded steel, with Van Stone joints and cast steel fittings. The use of steel pipe throughout for the feed water represents a marked departure from Delray practice in which brass pipe was used for the boiler leads and connections. In laying out the feed water system at Connors Creek, the design was so arranged as to permit of free expansion without the use of expansion joints of any kind.

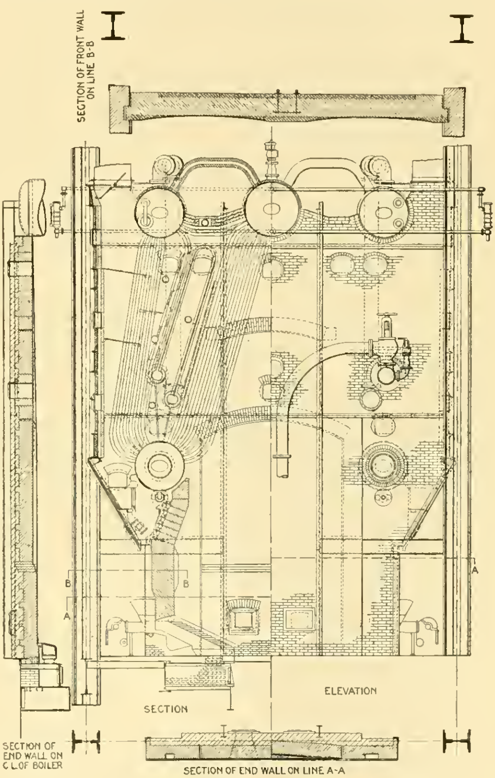


Fig. 6 Details of the Large Boilers

The boiler blow-off valves are also made by Hopkinson. These were decided on after two of them had been in satisfactory operation for several years at Delray. The valve is a parallel-seat gate, on whose stem is cut a rack which meshes with a pinion. A 180 deg. turn of the handle turns this pinion through a like angle and fully opens the gate. The superiority of the valve appears to be due to the use of excellent metal and to a very high class of machine work.

The main units, as previously mentioned, are rated at 25,000 k.v.a. or 20,000 kw. at 80 per cent power factor. The steam end consists of a horizontal, nine stage, 1200 r.p.m. turbine; the electrical end generates three phase, sixty cycle current at 4800 volts. A section of the turbo-generator unit is shown in Fig. 8. The steam exhausted from the turbine

passes down through a large expanding exhaust nozzle into the condenser, as shown in Fig. 5. Each condenser is built to contain 35,000 sq. ft. of heating surface made up of 1 in. tubes a little over 18 ft. long, but has only 32,500 sq. ft. installed. The tube heads have a diameter of 14 ft. 6 in.

The tubes are so arranged as to leave numerous lanes through the steam space, so that the vapor and air readily flow to all parts of the cooling surface. No baffles of any kind are used, excepting only those necessary to form an air box. The latter is located at the bottom of the condenser, as indicated in Fig. 9.

The condensate collects in a cylindrical hot-well which extends from the lower part of the condenser shell, and it is removed by either one of two hot-well pumps. These are motor-driven two-stage centrifugal pumps operated at 1200 r.p.m. and they are fitted with bronze impellers. The condensate is discharged into what is known as the cold end of the boiler feed tank, as will be explained later.

Circulating water is supplied to each condenser by a motor-driven single-impeller double-suction, volute pump. The motor is three-phase, slip-ring type arranged for a 15 per cent speed variation, the maximum speed being 400 r.p.m. During the period of the year when the circulating water has a high temperature, the pump will be operated at the highest speed and will deliver about 40,000 gal. per min. When the water temperature is low, the pump will be operated at the lower speed and the quantity will be proportionately reduced. The temperature of circulating water varies with the season from 34 deg. to 76 deg. fahr.

The circulating water enters the property through an open cut shown in the plan in Fig. 3 and thence flows through a concrete tunnel to the screen house. This tunnel has a free section 9 ft. 3 in. high by 10 ft. wide, and when it is supplying water for all of the units in the finished plant under the lowest water conditions on record, the water velocity will be just under 8 ft. per second; in obtaining this, further units are assumed to be larger than those now installed.

The water flows from this section of the tunnel into a sort of funnel-shaped enlargement which leads it to the screens. These are of the traveling variety and are similar to screens already installed in the Northwest Station in Chicago and at the Delray Station in Detroit. They consist of woven-wire panels fastened to the links of an endless chain, the lower end of the loop thus formed projecting down to the bottom of the water channel. The construction is shown in Fig. 10, which is a reproduction of a photograph taken in the interior of the screen house before it was completed.

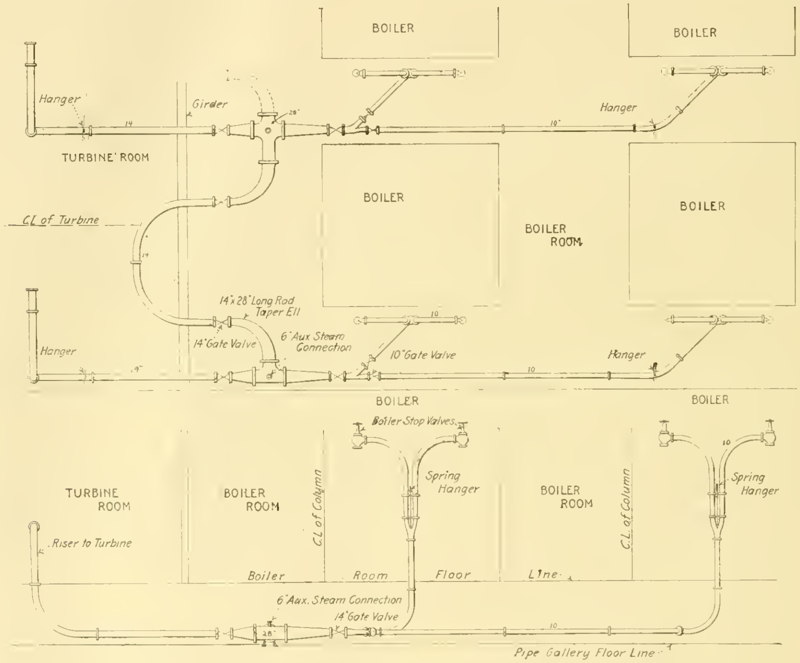


Fig. 7 Details of the High Pressure Steam Piping System

When a screen becomes fouled, the working side of the loop is drawn up and over the upper guide shaft, its place being taken by what was previously the back side of the loop. This operation brings the fouled screen panels under a wash pipe which washes the fouling material into a channel arranged to carry it to the overflow canal. The screens are operated by motors and are started and stopped periodically as required. Their constant movement is only necessary under exceptional conditions. Provision is made for returning water from the overflow tunnel into the intake to assist in keeping screens and tunnel clear of ice during cold weather.

After passing through the screens, the circulating water

is turned through a right angle and flows down the length of the house in a tunnel which is 15 ft. wide and 9 ft. 3 in. high. Water is picked up by the circulating pumps through large angle fittings encased in the side wall of this tunnel.

The water passes in the condenser are rather unusual. The entering water flows through the tubes occupying one vertical half of the condenser plus those enclosed by the air box, or cooler, at the lower end of the other vertical half. The water then returns through the tubes above the air cooler and overflows through a large cast iron nozzle and elbow which points down stream in the overflow canal.

Air and non-condensible vapors are removed from a header space in the cooler by means of a 35 by 39 in. rotative, dry vacuum pump. This pump is arranged for two-stage operation in one cylinder, one end of the cylinder serving practically to load the other. A direct-current motor with armature mounted on the crank shaft drives the unit. The normal speed of the pump is 100 r.p.m., but the motor is arranged for a speed reduction to 40 r.p.m. and need seldom be operated at or near its maximum.

head of a barometric condenser, as shown in Fig. 11. The relatively cold condensate is picked up by the second pump before it has time to mix with the mass of water in the tank, and serves as injection water for the barometric condenser. The house-service alternator turbine and the boiler feed pump turbine exhaust into this barometric condenser, so that the condensate from the main unit takes up all the heat of the auxiliary steam. The foot of the barometric condenser is immersed in the other (or hot) end of the boiler feed tank. The mixture is there picked up by the boiler feed pump and delivered to the boilers.

The barometric condenser is therefore the equivalent of an open feed water heater in which exhaust steam from auxiliaries mixes with and heats the condensate from the main units, the mixture passing to the boilers as feed water. This condenser, however, offers possibilities not possessed by the ordinary open heater in that it is capable of maintaining a very low back pressure, if this is desired, or can be operated at any pressure between this and atmospheric. This property, taken in conjunction with the great variation of the

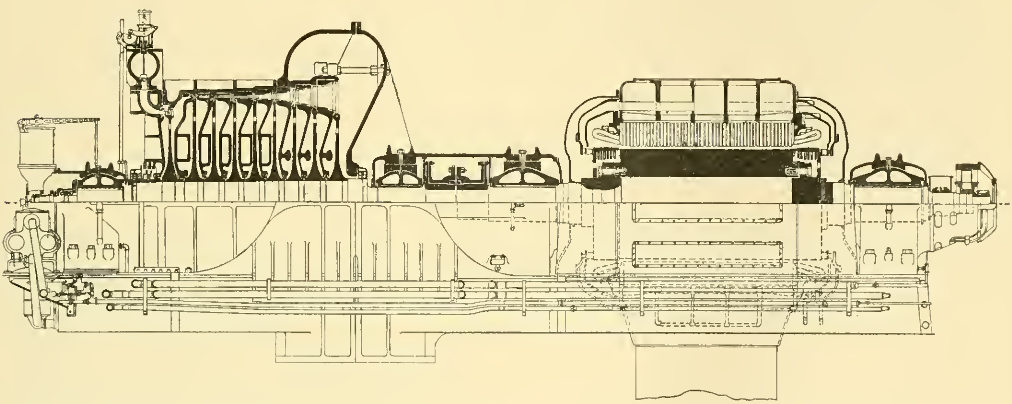

Fig. 8 Sectional View of One of the 25,000 k. v. a. Turbo-Generator Units

It will have been observed that all of the auxiliaries thus far mentioned are motor driven. As a matter of fact, this is true of all the auxiliaries in the plant with the exception of the boiler feed pumps. The latter are 1200 gal. per min., four-stage, double-suction, centrifugal pumps, driven by 350 h.p. steam turbines, at 2000 r.p.m.

The motor-driven auxiliaries may be operated, all or any of them, with power taken from the system bus, or with power taken from turbine driven, 1000 kw. alternators, known as house service alternators. In every case, that arrangement is used which, in conjunction with the other adjustments described below, will give the best heat balance for the station, under the conditions at the time existing.

What may be called the house service system is shown diagrammatically in Fig. 11. It is really a development of a method long used in both marine and stationary practice, in which a feed water heater is operated under vacuum. In the present instance, the wet vacuum pump of each main turbine unit discharges into one end of a large tank, known as the boiler feed tank. A centrifugal pump draws its water from the same end of this tank and discharges it into the

auxiliary turbine water-rate with variations of back pressure, gives great flexibility of control of the station heat balance.

This is shown diagrammatically in the upper left hand corner of Fig. 11. The straight lines represent total steam consumption of the house alternator turbines for the entire range of load at different back pressures. Assume that at some particular time with a given load and vacuum on the main unit, the load on the house alternator has the value indicated by the vertical line, and that the back pressure is that corresponding to the middle steam consumption line as at *a*. If the feed water temperature is too high it can be lowered by decreasing the back pressure, reducing the steam consumption to some such value as that shown at *c*. In this way, the feed water temperature can be accurately controlled, just enough auxiliary exhaust being made available to give the desired temperature.

The variation of the back pressure is obtained by means of a back-pressure valve in the exhaust line from the boiler feed pump turbine. If, under given constant conditions, this valve is partly closed down, the back pressure on the boiler feed pump turbine is increased and its steam consumption

for the same load is correspondingly raised. This, however, means that more steam enters the barometric condenser and, with a constant quantity and temperature of circulating water (main condensate), the temperature and pressure in the barometric condenser must rise. This, in turn, means higher back pressure on the house alternator turbine and it delivers more steam, still further raising the temperature.

Under certain conditions, this interchange may result in a cumulative temperature rise, ending only when the pressure in the barometric becomes equal to that of the atmosphere and the auxiliary exhaust blows to waste. To prevent such an occurrence, the flood valve shown in Fig. 11 is provided. This is automatically opened whenever the temperature of the steam entering the barometric condenser exceeds a predetermined value. When it operates it admits comparatively cold water from the storage tanks, adding it to the normal supply of injection water entering the condenser, thus bringing the temperature down very quickly. It then automatically shuts off. Under very poor conditions of adjustment, this valve would continue to open and shut periodically until all of the water in the storage tank and boiler feed tank had been heated to about 212 deg. fahr., but such a contingency is not probable because this would take a long time and the watch engineer would make necessary re-adjustments before the valve had acted many times.

The house alternator, boiler feed pump, and barometric injection pump are all grouped under the gallery shown at the right-hand side of the turbine room in Fig. 5. The natural position for the watch engineer is at the same place, so that continuous observation of this apparatus is readily obtained. An auxiliary gauge board containing instruments showing critical temperatures, pressures and quantities is located within easy view, and the results of all adjustments are readily seen.

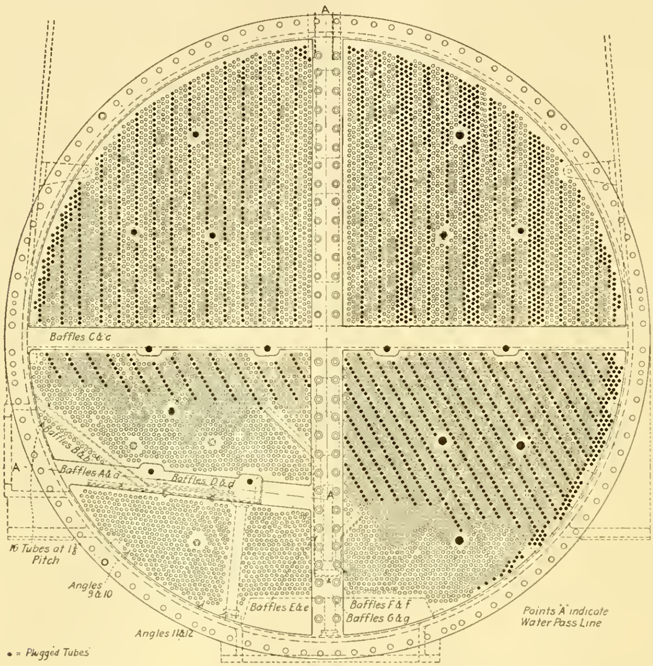


Fig. 9 Details of Tube Arrangement in the Condensers

This method of operating the auxiliaries appears very complicated when described on paper, but it has proved to be very simple in practice, and easy to handle. It possesses the following advantages which should be compared with methods more commonly used:

*First.* The one great advantage of steam driven auxiliaries is retained because exhaust steam is available for feed water heating;

*Second.* The quantity of auxiliary exhaust can be fitted to the ability of the feed water to absorb it;

*Third.* All the advantages of motor drive are obtained;

*Fourth.* Up to the ability of the feed water to absorb steam, the power used by the motor driven auxiliaries is produced at a thermal cost practically equal to that obtained in the case of steam driven auxiliaries;

*Fifth.* Since the feed water heater is normally operated under a vacuum, the feed water temperature is readily maintained at a value which will give ideal economizer operation;

*Sixth.* Because of the vacuum maintained in the feed water heater, air is readily removed from the feed water just before it enters the boiler feed pumps. In practice there is no reabsorption of air by the condensate between main condenser and boilers.

Another unusual feature is the provision for the distillation of all make-up water. Experience at Delray has shown that the quantity of make-up required is readily held down to 1.5 or 2 per cent. Under such conditions, the apparatus required for distillation is small and the cost is negligible in comparison with the cost of boiler labor saved. The evaporator installed has a capacity of 12,000 lb. of vapor per hour and is heated by high pressure steam. The vapor formed in it passes directly to the barometric condenser in which it mixes with the auxiliary exhaust and thus becomes part of the feed water.

Many cases of boiler pitting and corrosion which are recorded in engineering literature have been attributed to the use of very pure water and the presence of a small quantity of scale-forming material has therefore been regarded as desirable. Most authorities now seem to believe that pure water is not responsible for such damage to good boiler metal, but that the blame is to be laid on small quantities of atmospheric carbon dioxide dissolved in what is assumed to be pure water.

In the Connors Creek plant, the feed water heating and storing system has been so designed as to prevent the absorption of air, so far as prevention is readily possible. Should

experience show that the provisions made are inadequate to insure safe boiler operation, there are several simple remedies. The simplest is probably the use of a very small quantity of an alkaline salt, experience having shown that if the water shows a mere trace of alkalinity it is apparently noncorrosive.

Another innovation in this station is the very complete provision for the recovery of radiation and electrical losses. Air enters the turbine room principally through louvres above the air washer shown in Fig. 5. This air, after being washed if necessary, passes down through the turbine room, picking up part of the heat lost by the steam apparatus. Ultimately it is drawn into the generator, picks up the heat representing the losses therein, and is discharged through a duct below the turbine room floor. This duct carries the heated air into the pipe gallery in which the stoker blowers are located. On its way to the blowers the air passes around the outside of the covering of all steam pipes, so that it also picks up the heat which these surrender to the surrounding atmosphere. In this way a large fraction of these unavoidable losses is conserved by being delivered to the boiler furnace, and just that much less heat need be supplied by fuel.

The electrical end of the plant also contains several unusual features. Notably, the generator leads are tied solidly to transformers which have a one to five ratio. These step the voltage up to 24,000, at which voltage all metering and switching is done. One of these transformers is shown to the left of the turbine room in Fig. 5 and also near the lower part of Fig. 13. There are three 8,333 k.v.a., single-phase water-cooled transformers per turbine.

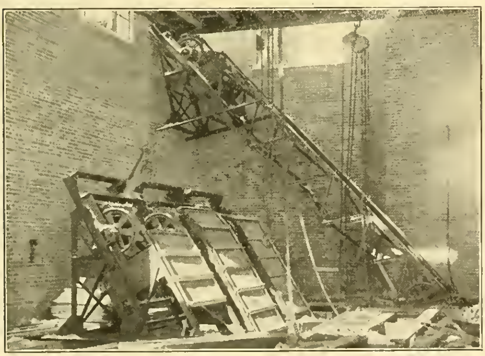

FIG. 10 INTERIOR OF SCREEN HOUSE

A semi-diagrammatic layout of the complete electrical system is given in Fig. 12. The turbines will really be arranged in one straight row when all are installed, but the bus is actually built in the form of a loop, as shown in the figure. Section switches are provided between bus sections corresponding to each turbine and each of these sections is, in turn, divided into two approximately equal halves, thus localizing the effect of breakdowns to the greatest feasible extent. These section switches are non-automatic.

All switches are mounted in separate compartments on the floor immediately above the bus structures, as shown in Fig. 13. All machine, section and feeder switches are motor-operated, oil-break switches and are provided with lock type disconnecting switches on both sides, so that they can be completely killed for cleaning or repair. The doors on the oil switch and disconnect compartments are automatically locked by the closure of the oil switch.

On the floor above the switch gallery are located the storage battery (for auxiliaries, switches, and signals), the switchboard, and small electrical auxiliaries such as a balancer set, battery charging boosters, and a control motor-generator. The switchboard is located at what will ultimately be the center of length of the power house and is built in two sections arranged back to back, as shown in Fig. 13.

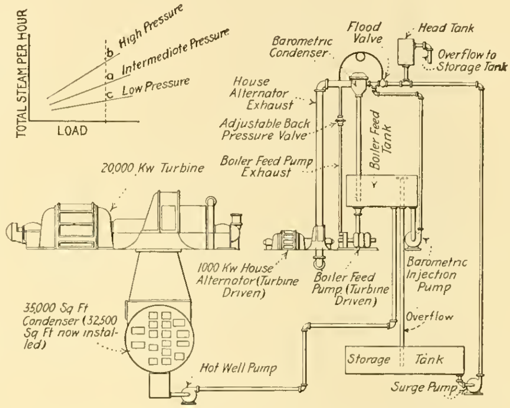


FIG. 11 ARRANGEMENT OF THE HOUSE SERVICE SYSTEM

The section facing the turbine room contains only the control switches and indicating instruments, while the rear board contains the integrating instruments and protective relays. All electrical equipment is controlled from this gallery, with the exception of the motor driven auxiliaries. The remote control switches for these are located to the left of the turbine foundation, as seen in Fig. 13. The auxiliary starting push buttons and the controllers for variable speed motors are located at the most convenient points, generally near the motor. The switch gear current for all apparatus handled from the main switchboard is supplied by the 25 kw. control motor-generator set mentioned above. This floats on a section of the storage battery, thus insuring continuity of service on the control.

In explanation of the fact that, as shown in Fig. 12, no reactances have been installed and that the design therefore diverges from recent practice, attention should be called to the fact that the inherent reactance of the apparatus connected to the busses, together with the nature of the bus structure, is such that no protective reactances are deemed necessary. Provision has been made in the bus structure for the installation of additional supporting insulators opposite to those already in place when the connected generator capacity becomes such as to demand additional rigidity, also for feeder reactances if changes of distribution methods later should make these desirable.

Each turbine is normally excited at 250 volts by an exciter mounted on an extension of the generator shaft. In ordinary operation, the armature of the exciter supplies the generator field directly, voltage control being effected by a motor-driven dial switch on the exciter's field rheostat. The gen-

erator field may also be excited from the direct-current house service bus, in which case it is controlled by a motor operated rheostat in the main field circuit. The house service direct-current bus which supplies the direct-current auxiliaries and the emergency excitation, is supplied by motor generator sets, one to each station unit. The station storage battery also floats on this bus insuring continuity of service.

The use of alternating current motors for some auxiliaries and direct current for others is determined by the following considerations: *a.* For any constant speed motor, alternating current was chosen. *b.* For speed variation of small range (as for the circulating pump where 15 per cent variation is sufficient), or of only occasional use (as the crane motors), alternating current motors with external resistances were chosen; except for the dry vacuum pumps, where the desirability of being able to start up from a condition of

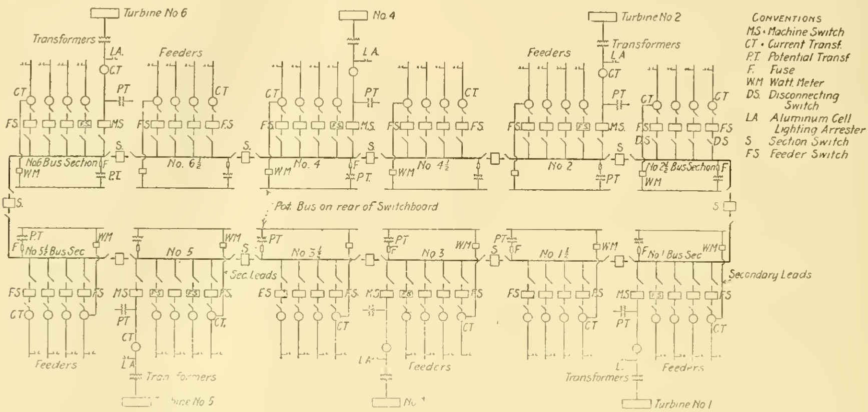


Fig. 12 Layout of the Complete Electrical System

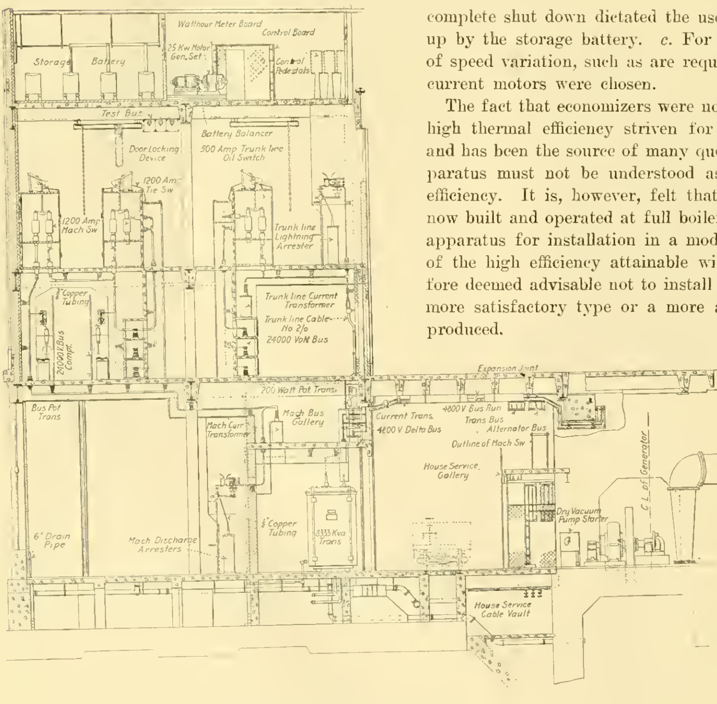


Fig. 13 Sectional View through Switch House

complete shut down dictated the use of a direct current motor backed up by the storage battery. *c.* For long ranges and exact adjustment of speed variation, such as are required by stokers and blowers, direct current motors were chosen.

The fact that economizers were not installed in this plant despite the high thermal efficiency striven for has caused considerable comment and has been the source of many questions. Failure to install such apparatus must not be understood as a declaration of disbelief in its efficiency. It is, however, felt that the cast iron tube economizer as now built and operated at full boiler pressure is not a proper piece of apparatus for installation in a modern high pressure plant. Because of the high efficiency attainable with the large boilers, it was therefore deemed advisable not to install economizers until such a time as a more satisfactory type or a more acceptable method of operating is produced.

Note. Since the presentation of this paper, the Connors Creek plant has been put in operation and thoroughly tested out. Small troubles, such as would be expected with a new and radical design of this sort have, of course, been met, but, on the whole, the plant has operated very smoothly indeed.

The operating record shows that the thermal efficiency of the plant will be about as high as was expected when it was laid down. The coal consumption per kilowatt-hour during the first two months of operation was considerably lower than the record performance of the Delray plant, and it is natural to expect that it will be further decreased as the operating methods are improved.

# BOILER FAILURES AND WHAT THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS IS DOING TO PREVENT THEM

BY E. R. FISH, ST. LOUIS, MO.

Member of the Society

THE use of vessels for generating steam under pressure is as old as the use of steam itself, and for just that length of time there have been boiler failures of different kinds. The art and practice of boiler making has steadily progressed from its beginning with low pressures, imperfect and ill-suited materials, mediocre workmanship and unscientific designs, but it is, however, still far from perfect as is evidenced by continued disasters of varying magnitude.

Much has been written on the subject of boiler explosions, but Prof. R. H. Thurston was the first to put the matter in concrete and scientific shape, and I am quoting freely from his writings, for he expresses the conditions far better than I possibly can. Professor Thurston enunciated the following principles:

*a* Steam boiler explosions are always the result of well understood causes and are only mysterious, in any case, in the sense that available evidence may not point out with certainty which of the various well known causes may have operated in the given case.

*b* Boiler explosions are always preventable; it is always practicable to so design, construct and manage steam boilers that there shall be absolutely no danger of explosion.

*c* The proper course on the part of the designer, builder and user is to first use forms of boilers wherever practicable, such that, as Col. John Stevens said a century ago, "their explosion shall not be dangerous even should overpressure occur"; the same idea was enunciated by Fairbairn. Insure next good and well tested materials, good and well inspected workmanship and uniformly skillful management by men of experience and reliability. Regular, effective and thorough inspection constitutes a part of good management and an essential part.

He further stated that "steam boilers are magazines of energy forcibly restraining explosive powers of such magnitude as few can compute or realize." As an example, I select from one of the tables he calculated covering a number of different types and sizes of boilers, a return tubular boiler of 60 h.p. working at 75 lb. pressure. The weight of such a boiler is approximately 9500 lb., the water it contains weighs 8200 lb. and the steam 21 lb. The available stored energy in the water is 50,008,790 ft. lb. and in the steam 1,022,730 ft. lb., or a total of 51,031,520 ft. lb., which is sufficient to project the boiler only to a height of 5372 ft. with an initial velocity of 588 ft. per sec.

Quoting further from Thurston:

It is seen that the energy stored in the steam boiler, in the form of heat, is mainly that of the heated water and comparatively little resides in the steam; so that it follows that a boiler well filled with water is vastly more dangerous in case it explodes, than if exploded as a consequence of low water. The steam itself is quite incompetent to perform the work of the very destructive explosions often observed, and where the boiler is thrown, with the violence of a projectile from a piece of ordnance, against surrounding objects or hundreds of feet into the air; for it must be remembered that in no case can more than a small fraction of this computed total energy be actually applied to the propulsion of the boiler. Most of it is inevitably wasted in other directions.

Comparing the energy of water and of steam in the steam boiler with that of gunpowder, as used in ordnance, it has been found that at high pressures the former become possible rivals of the latter. Taking the value of gunpowder at what the writer would consider a fair figure, 250,000 ft. lb. per lb., it is seen that a cubic foot of heated water, under a pressure of 60 or 70 lb. per sq. in., has about the same energy as one pound of gunpowder.

A powder magazine under one of our modern tall buildings, or under the sidewalk in Broadway, would be objected to very seriously by citizens compelled to make that great thoroughfare their daily walk, and if compelled to submit to its threatening presence, they would certainly insist upon the most stringent precautions being taken to insure safety against the liberation of its stored energy; but scores of steam boilers are so concealed and the laws of the city and of the State relating to their care are of the most lax and ineffective character.

Good design, good workmanship and good management have been said to be the three safeguards against destructive explosion. Good design, in any case, presupposes a well read, well educated and an experienced designer.

Good construction involves the selection of good materials and their proper use in building the boiler. This means, in turn, iron, or more commonly, steel in which ductility and toughness, rather than simple strength, are the special characteristics, and perfect uniformity in the several sheets of which the boiler is made up. Good construction involves the exact production of the required forms of parts and their riveting, or welding, together without loss of strength or introduction of stress. Good management means the regular and moderate firing of the furnace, constant inspection of the parts liable to corrosion or other injury, and maintenance in as perfect condition as possible by constant repairing of injured parts. It also includes the periodical inspection and test which now constitute the basis of insurance.

All failures are due to preventable and familiar causes that might be evaded by the designer, the builder or the operator. Whatever may be said of the many known and possibly unknown, the certain, the probable and the possible causes, mysterious or otherwise, of boiler explosions, it is certain that a boiler is practically safe for all time in the hands of a good engineer or fireman if originally well designed, well constructed and properly set. Its safety is assured by a correct system of inspection either on the part of the person in charge or of the official inspector, or, more usually and properly, of both working together honestly and in good faith. A correct system of inspection is the check upon every defect of design, of construction and of operation.

Inspection should be made at fixed regular intervals and should be conducted by an inspector experienced, reliable, of good judgment and absolutely conscientious. He should be accompanied in his inspection by the responsible man in charge of the boiler, and his examination should be deliberate, thorough and unimpeachable. The time should be so chosen that the work may be done satisfactorily, without haste or interruption. The method should be—careful examination by eye, hand and a light hammer, of every sheet, stay, brace, tube and rivet in the boiler. Defective riveting, the most common defect, should be looked for in every seam. Cracks in the seam, under the lap, are not unusual and are very difficult to find in many cases, but if undiscovered, they will be likely to prove disastrous. Corroded sheets and tubes, bad bracing, sediment and incrustation are all promptly de-

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tected and readily visible in any case. The thickness of thinned sheets, corroded on either side, or of blisters, may be judged by the action of the sheet under the hammer, and many defects, entirely invisible, are found by the experienced inspector by the hand and ear, reinforced by the use of this tool. It is evident that no inspection worthy of the name can be made unless with the boiler dry and empty, and accessible in every part. A design which does not permit this should be condemned offhand. Tests by hydraulic pressure, though useful, and in the judgment of the writer indispensable, cannot be, in any case, allowed to supersede the real inspection above outlined.

Whatever may be the fact, however, more perfect and effective methods of inspection must be legally introduced and well enforced before the steam boiler explosion can become extinct, with its resultant destruction each year of hundreds of lives and millions of dollars' worth of property. With such methods, universally practiced, steam boiler explosions will become unknown.

Written some 25 years ago, the advice thus given has been to a considerable extent followed, but there still remains much to be accomplished, particularly as regards proper state legislation.

There are approximately 1500 boiler explosions of varying intensities each year in this country, averaging 400 or 500 persons killed, 700 or 800 injured and many hundreds of thousands of dollars damage to property.

General methods for proportioning the several dimensions of the boiler structure have long been known and in general use, although modified from time to time by tacit consent as experience or new and improved materials and methods became available. These rules, if such they may be called, have varied greatly in details in various places, depending on the personal opinions and experiences of the man or men formulating them. It can readily be appreciated that with the great multiplication of such regulations in the past few years, manufacturers who do a wide interstate business have become confronted with a condition that is hard to meet. In addition there are the infinite variety of private specifications written by consulting engineers and others, that differ through exceedingly wide limits and which represent the judgment of one or at best a very few men. Under such conditions it is impossible to manufacture economically, for a boiler built to meet the requirements of one place may be rejected in some other locality.

In 1905 there occurred in Brockton, Mass., an explosion which caused $250,000 damage, the loss of 58 lives and 117 injuries. This aroused the State of Massachusetts to action, the result of which was the enactment of legislation providing for the licensing of engineers and firemen, and governing the construction, installation and inspection of boilers. A Board of Boiler Rules was created for the purpose of formulating construction standards; its labors resulted in the most complete, scientific and logical set of regulations that had ever been promulgated. These rules have been quite extensively copied all over the country.

However, the need of regulations that would represent the consensus of the opinion and experience of the whole country rather than that of any one locality, prompted Col. E. D. Meier, when president of the American Society of Mechanical Engineers, to appoint a committee to formulate such rules. After more than 3½ years' real work, including numerous and lengthy discussions, often heated and acrimonious, the A. S. M. E. Boiler Code, as it is popularly known, has resulted and represents as nearly as it is humanly possible what those who are best qualified to know believe to be the best boiler practice.

There is much in the Code that is absolutely new. Probably only such a body as formulated it could have prevailed upon certain antagonistic manufacturers of materials and fixtures to get together and agree on uniform specifications for their products. This is notably the case with safety valve manufacturers and tube makers; possibly the most remarkable achievement is the very definite regulations, most of which are entirely new, relative to safety valves.

The Code covers the construction of stationary boilers and allowable working pressures, and is divided into two parts. Part I, Section I, applies to new installations of power boilers; Part I, Section II, to new installations of heating boilers, and Part II applies to existing installations of all boilers. Obviously it is necessary to extend considerable leniency to boilers now in use, as to do otherwise would work a tremendous hardship on thousands of steam users.

In brief, the subjects covered by the Code are indicated by the sub-headings: *Selection of Materials,* wherein is specified what grades of materials may be used for various parts and places in the boiler; *Ultimate Strength of Material Used in Computing Joints,* in which unit stresses forming the basis of calculations are given; *Minimum Thicknesses of Plates and Tubes,* to prevent "skinning" the job; *Specifications* for boiler plate steel, rivet steel, staybolt steel, steel bars, steel castings, gray iron castings, rivet iron, staybolt iron, and tubes, all of course as pertaining specifically to boiler practice. Then follow under the heading: *Construction and Maximum Allowable Working Pressures for Power Boilers,* detailed rules for determining strengths and efficiencies of joints, etc., with examples and stating in what way much of the work shall be executed. Then come the subjects of *Manholes, Washout Holes, Threaded Openings, Safety Valves, Water and Steam Gauges,* and *Fittings and Appliances,* wherein are given methods for determining quantities, sizes, limitations as to location and kind of metals to be used. Some general regulations as to settings to promote safety in operation, as to how hydrostatic tests shall be made and finally the method of stamping to show conformity of the structure with the Code, are given.

The rules covering boilers used exclusively for heating cover substantially the same ground, but are much more brief.

In Part II appear the rules for determining the working pressure to be allowed on existing boilers, and what fittings must be provided and how applied. On boilers now in service, will be required many minor changes if the Code is followed, but there are none but what should be made in any event. This section also provides for the gradual amortization, to use a commercial and financial term, of boilers now in use and not built to the Society standard.

An *Appendix* gives full examples of various riveted joints and methods of calculation, as well as of braced and stayed surfaces, method of computing safety valves, also how fusible plugs should be located in the various types of boilers, and standard dimensions for flanged pipe fittings.

In my opinion it is amply sufficient for any one desiring to purchase a boiler plant, after having determined the working pressure and the size and type of units required, to merely specify that the boiler is to be built according to the A. S. M. E. Code. By so doing he will get from any reputable

manufacturer a well constructed structure entirely suited to its purpose. If preferred, the material and workmanship may be checked by some inspecting agency. From a manufacturer's standpoint, my plea is for country-wide uniformity of requirements, and this the general adoption of the Code makes possible. It couples together economical manufacturing with the all-pervading cry of Safety First.

In compiling this Code, therefore, the American Society of Mechanical Engineers has provided a substantial basis for boiler specifications and legislation. The Society cannot go further than to say that, in the estimation of those best qualified to judge, these are the most rational rules and regulations for boiler construction. The enforcement of the rules must be left to the activities of other agencies. A very considerable number of the boiler manufacturers of the country have already gotten together on two occasions, first, on September 19, 1914, and again on March 29, 1915, with the avowed purpose of furthering the universal use of the Society's Code, and at the last named meeting, the Code was unanimously endorsed and steps taken to launch a movement to prevail upon the various States to enact legislation putting it into legal effect. It seems impracticable to do this in any other way. The State of Ohio has already made this enactment and the State of Wisconsin will in all probability do so, to be effective January 1, 1916.

Educational movements will have to be started in various other States in order to be at all sure of any success at future state legislative sessions. Last fall it was hoped that the Code would be completed in time to present the matter definitely to the numerous legislatures that were in session early this year, but that proved to be impracticable. One of the forms of education is to persuade those who have positive ideas of their own that such should be subservient to this broader consensus of opinion, and only by so doing can country-wide uniformity, so exceedingly desirable, be attained. Already there are some objections raised to minor points, which indicate that there are difficulties to be overcome in arriving at the desired end.

That this effort of the Society in bringing out the Code will help tremendously, primarily in bettering boiler construction generally, and secondarily, in smoothing the way of manufacturers, thus redounding to the financial benefit of the user, needs no further argument. The Code has already attained such momentum as to make it a powerful factor.

It can truly be said that what the American Society of Mechanical Engineers is doing to prevent boiler failures in this country is something which could have been done by no other organization and that the effect will be far reaching and long continued.

Note. Since this paper was written, an action has been taken at the annual convention of the American Boiler Manufacturers Association, June 22, to start a nation-wide movement including every interest in any way affected. This has resulted in the formation of the American Uniform Boiler Law Society, whose function will be to promote the adoption of the A. S. M. E. Boiler Code by legislative bodies.

# TURBINES VS. ENGINES IN UNITS OF SMALL CAPACITIES

By J. S. Barstow,[1] Philadelphia, Pa.

Non-Member

The term "units of small capacities" as used herein is intended to include steam turbines and engines of less than 500 h.p. capacity. The paper will necessarily deal largely with the prime movers of auxiliary apparatus in power plants, since the tendency of the times in all industries, and particularly in central stations, is toward the concentration of power in a few units of large size and uniform capacity as opposed to a multiplicity of small units of different capacities. However, there is a wide field for power application where the steam-operated prime movers are of relatively small size, and where transmitted or central station energy is not able to successfully compete; and it is intended to discuss the type of apparatus best suited in these cases, as well as the type of apparatus which it is advisable to employ for auxiliary units in large plants or central stations.

There are certain definite fields where the small turbine is of conceded superiority, and other fields wherein the engine must hold sway. The desirability of the one as compared with the other is largely determined by the following factors, which govern the adaptability, cost and economy of the equipment to be installed for any given service:

*a* *Speed conditions and limitations* involving consideration of maximum or minimum permissible speed, and whether the driven apparatus is of the constant or variable speed class

*b* *Steam pressure and temperature conditions* involving consideration of initial and final pressures, and superheat, if any

*c* *Power capacity of apparatus*

*d* *Relative space requirements of turbine and engine units* involving consideration of available room, character of power house construction and cost of foundation or other supporting structure

*e* *Use or application, if any, of the exhaust steam* for feed water heating, steam heating or process purposes

*f* *Available cooling water supply,* if the turbine or engine is to run condensing, involving also consideration of the temperature of the water and whether it must be artificially cooled and re-circulated

*g* *Operating conditions* including consideration of attendance, oiling, starting and stopping, vibration, noise, etc.

*h* *Relative cost of complete installations* including necessary foundations, piping and condenser equipment, if any

As to the practicability of the small turbine, it may be said that not until about 20 years ago was any really practicable apparatus of this kind developed, and even up to ten years ago the turbine was looked upon mainly as an experiment. The last few years have witnessed, however, the practical perfection of this type of prime mover in sizes

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Presented at the Philadelphia local section of The American Society of Mechanical Engineers, April 12, 1915.

as large as 50,000 h.p., with units of 30,000 h.p. quite common in large central stations. They have also seen quite as much good work done in the perfection of small turbine units as in the development of very large ones, and the turbine in all sizes is quite as well developed to-day as is the steam engine after more than one hundred years of constant effort and improvement.

The writer has no intention of reflecting on the great work done by steam engineers in the development of the reciprocating steam engine. The work of these men, which was the harder task, accelerated the evolution of the turbine, the science of thermodynamics underlying the final development and perfection of both.

The present day builders of reciprocating engines are able to report further progress, however, and as a result of their recent efforts there have appeared the rejuvenated poppet valve engine adapted to the use of highly superheated steam; the unaflow or parallel-flow engine, also with poppet type valves, in which cylinder condensation is reduced by causing the steam to travel in one direction only; and the small self-contained power plant, or "locomobile," consisting of a steam engine mounted upon a tubular boiler and operating at high superheat. All these engines are adaptations from European practice, where, owing to the high cost of fuel and the relatively larger number of technically-trained operators, they have found high favor.

Mention also should be made of the power plant formerly used in the White motor car, which, owing to its high steam pressure, superheat and speed, gave remarkably low steam consumptions. In a series of tests, reported in the Transactions of the Society, Vol. 28, pages 598-9, the average steam consumption was 12.7 lb. per delivered h.p.-hr., operating at 850 r.p.m.; steam at 275 lb.; superheat, 349 deg. fahr.; noncondensing exhaust.

Tests have recently been reported by the manufacturers which give the steam consumption of a 115 h.p. Buckeye-mobile, running at 248 r.p.m.; steam at 210 lb.; initial superheat, 171 deg. fahr.; noncondensing, as 13.3 lb. per i.h.p.hr. This unit produced an i.h.p.hr. on 1.33 lb. of coal having a calorific value of 14,500 B.t.u. per lb. A 169 h.p. unit running at 200 r.p.m.; steam at 209 lb.; initial superheat, 218 deg. fahr.; vacuum 25.7 in., showed a water rate of 9.2 lb. per i.h.p.-hr. The coal consumption, using fuel with a calorific value of 14,209 B.t.u. per lb., was 1.08 lb. per i.h.p.-hr.

While there is the possibility that the use of a shell type of boiler for high pressures will be considered by many engineers as unwise, especially for installation in densely populated centers, it is still too early to predict what the future of this apparatus is to be. However, as indicating what may be accomplished in fuel economy in a well-designed plant of small size, the results reported are interesting.

### SPEED LIMITATIONS

The question of speed limitations is of first importance in selecting the type of prime mover. Since high peripheral velocities are necessary in order to efficiently utilize the energy of a steam jet in the turbine type of apparatus, the latter shows its lowest water rate when running at a constant high speed. Where the character of the service is such as to require speed variation or reversal in direction, or where the speed is necessarily low, the turbine is unsuited and the engine is much better adapted.

In engine installations, the minimum permissible speed has an important bearing on the question of operation. If an engine is run at very high speeds, operating troubles are sure to be numerous, the upkeep excessive and the service unsatisfactory. The lack of driven apparatus designed to run efficiently at speeds consistent with high turbine economy has, in the past, frequently dictated the use of engine prime movers for many kinds of work.

Although speed reduction gears are by no means new, having been used with the turbine almost from the beginning of its commercial development, improvements in high speed gearing, as well as in the manufacture of high speed direct connected generators, blowers and pumps, running at 3,000 r.p.m. and above, have greatly increased the possibilities for turbine installations. Direct current generators as small as 10 kw. capacity, and 60 cycle alternators of capacities as low as 150 kw., designed for gear drive, are now offered. The manufacturers claim for these machines that the increased efficiency of the higher speed turbine, together with the saving effected in the generator construction by reason of the slower speed permissible in the driven end, justify the expense and complication which the gears introduce.

While many may still prefer a direct connection, the increasing popularity of the gear drive, especially for direct current generators, blowers and pumps, would seem to indicate that the gears are here to stay, and that when properly constructed and installed, there is no valid objection to their use.

For power station work, where some of the auxiliaries are usually motor driven, the exhaust steam can be entirely condensed in the feedwater heater, and the water rate of the steam driven auxiliaries is not a limiting factor, while reliability, accessibility, low maintenance and labor costs are of more vital importance. Power station designers have always exhibited, therefore, a strong preference for turbo-auxiliary units, and there is now a decided tendency toward geared installations.

The selection of turbines for auxiliaries is largely influenced by the high speed at which small engine units are run, which makes it exceedingly difficult to keep them in continuous service, and almost impossible to secure smooth, quiet operation. Such reciprocating units require close attention, and must be shut down, overhauled and adjusted at frequent intervals; the maintenance is high and serious breakdowns are by no means rare. An accident to a circulating or hot well pump, for example, usually necessitates a shutdown of the main generator, with consequent loss of production, and often, in the case of a public utilities plant, loss of prestige and the incurrence of public ill-will. In all central stations, therefore, where the main units are few in number and of large size, high economy as compared with continuous operation becomes relatively unimportant, and turbine driven circulating hot well and boiler feed pumps are almost invariably used.

Motor driven exciters are largely used in alternating current stations, a steam driven exciter being provided for starting up and as a reserve unit. Here also, since the steam driven set is idle a large part of the time, high economy is not so important and the saving of floor space and elimination of vibration will often decide the question in favor of the turbine. In fact, in all direct current generator sets of 50 kw. capacity or less, the high speed necessary for the engine generally makes it undesirable.

For driving fans of large capacity at low pressures, say less than $1\frac{1}{2}$ in. of water, for induced draft, hot air heating and ventilating systems and the like, the engine seems best suited. Fans built for this service ordinarily run at less than 200 r.p.m. and are usually of the paddle-wheel type, which is better suited to these conditions than the multiblade high speed fan. In induced draft work, load fluctuation may require frequent changes in speed, the engine being under the control of a throttling regulator which is automatically actuated by a change of steam pressure. These conditions are quite unfavorable to turbine economy, and a suitably designed and well-constructed engine will give more satisfactory results.

In like manner, where we consider the pumping of large quantities of water against low variable heads (conditions which are encountered in drainage or sewage pumping stations) the turbine must yield place to its rival. These pumps may have single runners of large diameters or may be of the multi-impeller type, but in either case, the speed is below the economical turbine range, even when a gear is used, while the engine, at low speed, has an opportunity to make its best showing, steam economy and operating troubles considered. Where the lift is variable, speed changes are required and the engine is almost always more suitable.

As a typical installation may be mentioned the four 76 in. centrifugal pumps for the Placquemine and Jefferson Drainage District of Louisiana. Here the pump speed varies from 50 r.p.m. for 1 ft. head and 135,000 gal. per min. to 115 r.p.m. for 13 ft. head and 90,000 gal. per min. The best duty was 92,600,000 ft. lb. per 1000 lb. of dry steam, corresponding to 21.4 lb. of steam per water horse-power obtained at 87 r.p.m. for 7 ft. head and 130,000 gal. per min. The prime mover is a compound engine operating at 170 lb. steam and 25.7 in. vacuum.

The use of underfeed stokers operating under heavy forced draft and capable of developing high boiler ratings, has become quite common as a means of reducing fixed charges and boiler banking losses in railway and lighting plants, and particularly those maintained as standbys to hydro-electric stations. These furnaces often carry in the air duct pressures as high as 6 in. of water, and the high speed multiblade fan makes the better installation, particularly where one fan serves several boilers, as the blower units frequently become excessively large when run slower than 400 r.p.m. At this speed the engine drive is an uncertain and expensive proposition.

Furthermore, as such stokers at best are capable of only from one-quarter to one-third their maximum capacity under natural draft conditions, a blower breakdown under a peak load is a serious matter and the ability of the turbine to stand up under the conditions imposed justly entitles it to the preference which it is accorded.

For driving directly connected alternators, a frequency of 25 cycles fixes the maximum speed at 1500 r.p.m., which is too low for the best turbine performance. In 60-cycle apparatus, where a speed of 3600 r.p.m. is possible, the turbine shows to better advantage.

### STEAM PRESSURE AND TEMPERATURE CONDITIONS

The highly economical steam turbine must necessarily be operated condensing, but, as previously pointed out, there are many cases where high steam economy is not the most important consideration and the noncondensing turbine often finds favor over the steam engine. One of the large heat losses incurred in the steam engine is that due to cylinder condensation and one of the common methods of reducing it to limit the range of temperature through which the steam is allowed to work in a single cylinder. For this reason simple engines are better adapted for low steam pressures, while compound and triple expansion engines are advisable for high pressure and high temperature ranges, particularly if the load is uniform.

The engine as a rule develops mechanical troubles with high superheat, especially where the steam valves have much travel under unbalanced pressures. The consensus of opinion seems to be that for slide or gridiron valve gears, a temperature of 400 deg. fahr. to 425 deg. fahr. should not be exceeded, while the best point for the Corliss type engine will be found below 450 deg. fahr. Above these limits lubrication is unsatisfactory and distortion of the parts is apt to give trouble.

In European practice, superheating is much more common than in this country, a superheater being considered quite as indispensable as a feed water heater and the poppet valve engine, which was first perfected abroad, is accordingly better suited for high superheat conditions than the type of gear commonly used in American engines.

A difficulty sometimes encountered with engines using high superheat is the warping of the cylinder, the curvature being caused by the higher temperature which prevails in the metal next to the steam chest. Precaution is taken by some builders to avoid such trouble by leading the steam by two independent pipes, entirely separate from the cylinder barrel, from the throttle directly to the steam valves.

For power plant auxiliaries, it would appear that turbines which experience little difficulty from high temperatures will be more and more widely adopted while engines will be less commonly used, especially so as steam pressures and superheats are constantly increasing, it being not unusual for new plants to be designed to carry from 200 to 225 lb. with superheats of 150 deg. fahr. and over. With steam engines running under high vacua, above 27 in., the great volume of steam to be handled increases the size of the engine cylinders, and the size of ports through which the steam must pass, to such an extent as to make the engines very expensive if not of impracticable construction. The cost of an engine which would permit of complete expansion to such a terminal pressure, together with the increase in cylinder condensation, due to the greater range of temperature, would make the high vacuum undesirable.

The turbine, on the other hand, can be designed to operate on very low terminal pressures with comparatively slight increase of cost; its action as a heat machine is such that a greater expansion can be utilized and the economy is greatly improved by any increase in vacuum. When run non-condensing, as is well known, the turbine is less economical than the non-condensing engine.

In plants where the exhaust is atmospheric and cannot be applied to any useful purpose, the engine best fills the conditions, provided space is available and the speed may be made low enough to ensure smooth, quiet running. Such an application is found in direct current generator sets of 100 kw. capacity and larger, in hotels, office buildings and hospitals, where the exhaust is used for steam heating in winter and must be wasted for several months in the year.

### POWER CAPACITY OF APPARATUS

The lower cost of large turbine units and the greater reliability of this kind of apparatus in regular service, coupled with the smaller space taken up by turbines as compared with engines, has practically put the engine out of the running as far as large power plants are concerned. Where 60-cycle apparatus is installed and condensing units are used, the engine has no field beyond the 500 kw. mark, while with direct connected 25-cycle apparatus, the engine must stop beyond the 1000 kw. limit, and with the perfection of high speed reduction gears, it is doubtful if 25-cycle engine driven generators can compete with turbine apparatus of even 500 kw. capacity. The reduction gear is also rapidly driving the engine from the direct current field in units of all sizes, above say 200 kw. capacity. At the same time, elimination of operating troubles by the use of direct connected turbines for exciter purposes is fast causing the turbine to supplant the engine for this service.

In the case of non-condensing units where moderate speeds are required, the engine must continue to hold the field, though special conditions may make the non-condensing turbine a factor to be considered. In this connection, one installation might be mentioned where a belted turbine of 750 h.p. capacity, running at 1500 r.p.m., is used for driving the constant speed shafting of a paper mill, it being contended that the greater uniformity in rotative speed secured by the turbine results in fewer breaks and a more satisfactory product. In this case, the exhaust steam is, of course, utilized in the dryers of the machine, and the variable speed power is supplied by direct current motors.

### RELATIVE SPACE REQUIREMENTS

Owing to the freedom from reciprocating motion, the foundations required for turbines are of small size and light weight, there being little vibration to be absorbed when the alignment and balancing are well done. The small sizes can be safely operated on floors of usual construction, designed for the ordinary floor loads. There is no difficulty experienced with the transmission of vibration to the structural members of the building or to the piping system.

The small space required for the installation of a turbine gives it an advantage in water works plants, operating against moderately high heads. The vertical triple expansion engine, which was formerly used almost exclusively for such work, requires a strong massive substructure to absorb the shock and distribute the weight, and a deep pit to accommodate the water end. Where foundation or other construction difficulties are encountered in this work, the cost may easily climb to a high figure, and in a case under the author's personal observation the additional cost of building, incidental to the use of the vertical triple engine, would have more than paid for a turbine driven centrifugal pump, while the fixed charges on the pump alone were more than four times the cost of the fuel required to run it to full capacity ten hours per day.

The turbine driven pump is not capable of showing on test the high duty of the vertical triple engine—which is one of the most economical steam engines—but the great difference in the first cost of installation often makes the turbo set decidedly preferable, especially when the saving in building is considered. A geared turbine unit to pump 100 million gallons per day against a 56 ft. head was recently installed in Ross Station, Pittsburgh; the pump speed was 350 r.p.m. and that of the turbine 3600 r.p.m. On the duty trial, with steam at 151 lb. and vacuum 28.38 in., the pump showed a performance, including power consumed by the auxiliaries, of 120.5 million ft. lb. per 1000 lb. of dry steam, corresponding to 16.44 lb. of steam per w.h.p.hr. Six similar sets, ranging in capacity from $6\frac{1}{2}$ to 30 million gallons per day capacity, are now in process of construction. The displacement of the reciprocating engine from a field where its superiority was formerly unquestioned, shows the substantial progress which has been made in the development of the steam turbine and the centrifugal pump.

For boiler feed pumps of more than 250 gal. per min. capacity, the turbine is often used, and on account of its small size, usually results in a neater and more compact layout. Where regulation by throttling is unnecessary, and the pumps run at or near capacity, the economy as compared with the direct acting type is good and can be better maintained. Valve renewal and packing troubles are avoided. The overload capacity of the centrifugal type, however, is small and the delivery of the pump must be proportioned to meet the maximum demand, not the average boiler horsepower requirements. In the smaller sizes, the cost of turbine units is high; where the load fluctuates widely and the speed must vary, the economy is poor and it is better to install reciprocating pumps.

In the modern plant containing large turbo-generator units, space limitations in the basement arrangements are an important consideration. With the high vacua carried, large volumes of water must be handled and the turbine drive for circulating, condensation and air removal pumps is in many cases the proper selection. Such condenser sets have a compact arrangement, especially when a single turbine is used to drive all the pumps, which greatly relieves the crowded condition that would otherwise obtain. As previously stated, they are also preferable as being more reliable.

The turbo-compressor supplying air to blast furnaces under pressures ranging from 20 lb. to 30 lb. has almost entirely supplanted the compound reciprocating blowing engine. One large concern formerly in this work has abandoned the construction of blowing engines and is now building turbine apparatus exclusively. For this service, the turbine may be run from 2500 to 4000 r.p.m., and there is a great saving of weight and space, as an engine of this type is six or eight times as heavy as the centrifugal blower, and consequently costs much more. It can be installed comfortably where the blowing engine would be out of the question, and in new installations the relative cost of building and foundation for the two types has a direct and important bearing.

### UTILIZATION OF EXHAUST STEAM

The advantage of an oil-free exhaust is in many plants of considerable value, and especially so in manufacturing processes where steam is used, as there are many such opportunities for the utilization of low pressure steam if the oil has been eliminated. For the blocking of hats and in the treatment of other felt and textile products, absolutely clean steam is necessary. As heretofore mentioned, paper manufacturers have used turbines for driving the constant speed mechanism of paper machines in order to secure more uniform angular velocity, and to avoid among other things

trouble caused by oil accumulation in the drying rolls. The danger of oil deposits in high pressure steam boilers is well-known to all.

In chemical processes where steam is used for precipitation, as in the precipitation of magnesia, a small fraction of a grain of oil per gallon will often retard the process or cause the precipitate to be of an entirely different character from that obtained with oil-free steam. The separation of the oil in exhaust steam is never absolutely complete, and fatty constituents are especially apt to pass the separator.

### AVAILABLE COOLING WATER SUPPLY

Where the available cooling water supply is limited and must be artificially cooled and recirculated, the cost of the cooling apparatus and the power required must be considered. The conditions will, perhaps, be best illustrated by an example: Assuming a turbine to run at 28 in. vacuum, and a temperature rise of the cooling water to within 10 deg. of that due to the vacuum, the circulation of 52 units by weight of cooling water for each unit of steam condensed will be necessary. In the case of the engine, which will operate at, say, 26 in. vacuum, other conditions remaining the same, there will be from 25 to 27 lb. of cooling water to be handled for each pound of steam condensed.

With a cooling pond returning water at 90 deg. to produce 27 in. vacuum in a turbine plant, the pumps must circulate 70 units of cooling water per lb. of steam, as against, say, 30 units required to produce 25 in. vacuum for the reciprocating engine.

### OPERATING ADVANTAGES

From the operating point of view, the turbine possesses a great advantage in the simplicity of its construction, a factor which tends toward increased reliability and lower cost of maintenance. It can usually be more quickly started and loaded and, in operation, usually requires very much less attention than an engine unit of corresponding capacity. The lubricating arrangements are few in number and of simple design.

### SUMMARY

Summarizing the foregoing, the fields of usefulness of the turbine and engine may be briefly stated to be:

### APPLICABILITY OF TURBINES

1 *Direct connected units, operating condensing.* 60-cycle generators in all sizes, also 25-cycle generators above 1000 kw. capacity. (This paper is, however, not intended to deal with units of this size.)

Direct current generators in sizes up to 1000 kw. capacity, including exciter units of all sizes.

Centrifugal pumping machinery operating under substantially constant head and quantity conditions, and at moderately high head, say from 100 ft. up, depending upon the size of the unit.

Fans and blowers for delivering air at pressures from $1\frac{1}{2}$ in. water column to 30 lb. per sq. in.

2 *Direct connected units, operating non-condensing* for all the above purposes, in those cases wherein steam economy is not the prime factor or where the exhaust steam can be completely utilized, and, in the latter case, particularly where oil free exhaust steam is desirable or essential.

3 *Geared units,* operating either condensing or non-condensing for all the above mentioned applications, and in addition, many others which would otherwise fall in the category of the steam engine, on account of the relatively slow speed of the apparatus to be driven.

### APPLICABILITY OF ENGINES

1 *Non-condensing units, direct connected or belted* and used for driving:

Electric generators of all classes excepting exciter sets of small capacity, unless belted from the main engine.

Centrifugal pumping machinery, operating under variable head and quality conditions and at relatively low heads, say up to 100 ft., depending on the capacity of the unit.

Pumps and compressors for delivering water or gases in relatively small quantities and at relatively high pressures—in the case of pumps at pressures above 100 lb. per sq. in. and in the case of compressors at pressures from 1 lb. per sq. in. and above.

Fans and blowers (including induced draft fans) for handling air in variable quantities and at relatively low pressures, say not over 5 in. water column.

Line shafts of mills, where the driven apparatus is closely grouped and the load factor is good.

All apparatus requiring reversal in direction of rotation, as in hoisting engines and engines for traction purposes.

2 *Condensing units direct connected or belted,* for all the above purposes, particularly where the condensing water supply is limited, and where the water must be re-cooled and re-circulated.

# SPRING MEETING PAPERS

*IN the August issue of The Journal were published eight of the fourteen papers presented at the Spring Meeting held at Buffalo, June 22-25. The six remaining papers are here published in abstract, together with accounts of the discussions following them. Pamphlet copies of the complete papers without the discussion are available at the prices named in each case. Later, the papers which are to appear in Volume 37 of Transactions, may be had in pamphlet form with the discussion added.*

## SOME MECHANICAL FEATURES OF THE HYDRATION OF PORTLAND CEMENT AND THE MAKING OF CONCRETE AS REVEALED BY MICROSCOPIC STUDY

BY NATHAN C. JOHNSON, NEW YORK, N. Y.

Member of the Society

THE data embodied in this paper have been obtained in the course of a research conducted in the Sibley College laboratories at Cornell University. At the beginning of this research, it was believed that the obtaining of more effective hydration was a prime factor in the production of durable concrete. It has long been known experimentally that a set cement or concrete could be reground and a new set obtained on gaging with water;[1] but the extent to which unhydrated particles were present in the mass was first made visually evident, so far as the author is aware, by experiments conducted in 1911 in the Sibley College laboratories at Cornell.[2] In these experiments, neat cement briquettes were surfaced and polished, as in the metallography of steel; and the degree of hydration obtained in different ways was more or less accurately judged by the appearance of these polished sections, viewed through the microscope. Later this same procedure was extended to the examination of 1.3 standard sand mortars and still later to the examination of field concretes.

In a section of such 1.3 mortars photographed through the microscope (shown in Fig. 3), the grains of sand show as large as boulders and each has a well-defined shadow. Further, since only cement and a sand of known size were used in the briquette, the "rocks" between the boulders can be nothing other than cement; and this cement must be unhydrated, since its color by direct vision, varying from light green to dark brown, and its resistance to the cutting of the polishing powders used in preparing the surface to remove the portion known to be hydrated, both testify to the same fact.

Such disclosures as these were the basis on which was undertaken the original research by the author, of which this Industrial Fellowship research was a later outgrowth. Since such structures were found to be typical of all mortars examined, and since cement is the most variable constituent of any mortar or any concrete, it was argued that any process which would insure thorough hydration of the cement particles would render possible the use either of higher unit-stress values, or of less cement for present allowable values, with a most pronounced saving in either case, both in materials and money.

From the nature of this investigation, it is at once evident that progress would have to be measured by checking values obtained by the apparatus against those obtained with the same materials under standard conditions of mixing and moulding. In addition to the standard physical tests, it was also proposed to carry on a study of the microsections of each set of specimens broken. To facilitate such a comparative study, record books were prepared for both hand and machine mixes, the hand mixes being designated by the letter *H*, followed by a serial number, with results recorded below; and the same data for machine mixes, designated by the letter *P* (pneumatic) followed by a serial number, are placed on the opposite page. The position of the break of each briquette was recorded in the outline form. Although not recommended for general use, this has proved of very great benefit in reconciling otherwise discordant results.

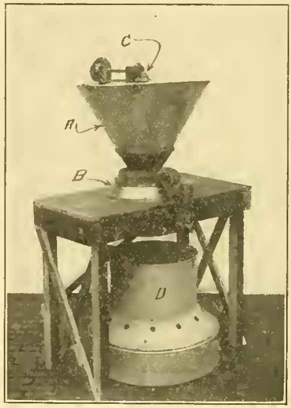


FIG. 1 IMPROVED FORM OF HYDRATOR

In Fig. 1 is shown one of the latest forms of hydrator used, which was believed to include the essential features of earlier types with the mechanically troublesome parts refined. In this photograph, *A* is a hopper, of sufficient size to contain a whole bag of cement; *B* is the atomizer, with the jets increased to forty-eight; *C* is a feed-device of coffee-mill type, driven by an electric motor; and *D* is a container with baffled exits. In spite of the fondest hopes and the most strenuous labor, this machine failed in its purpose, so far as really notable results are concerned. As the re-

[1] H. Sager & E. Cramer. Touind Zeit, 1908, 32, 1746.

[2] Master's Thesis by N. C. Johnson, Cornell University, 1913.

Presented at the Spring Meeting of the Society, June 1915. Complete paper may be obtained without discussion; price 15 cents to members; 30 cents to non-members.

search proceeded, it was found that there originally had been considerable misapprehension as to the causes of faulty hydration, though not as to the extent or degree to which hydration commonly proceeds. The obtaining of better hydration is a very vital problem in the concrete industry, but to effect this on a commercial scale in the manner above outlined would be virtually impossible.

In regard to the microscopic investigation of cements, the process is, in general, similar to the microscopic examination of steels in metallography which has already proven of the greatest benefit to the steel industry. And as is done with specimens of steel, a single surface only is polished, the structure of this being developed by various reagents and observed through the microscope by reflected light. This renders possible the ready examination of composite materials, which would otherwise require the greatest patience and skill in their preparation.

The use of the photographic camera in connection with the microscope is but carrying the process a step further. On the microscope stage is mounted the polished and surfaced specimen, on which the light is concentrated by a bull's-eye lens. Above the eye-end of the microscope is mounted an ordinary photographic hand-camera with its proper lens removed; and on the ground glass at the top, for which may be substituted the sensitized plate, is projected the enlarged image of the structure of the specimen.

To ensure a thorough understanding of the evidences and effects of hydration of cement, it may be well to consider here the nature of the processes involved. The completed cement derives its usefulness from the hardening produced shortly after its admixture with water. There are, however, two stages in the passage from the semi-fluid state of gaged cement to that of the hardened. In the first stage the mass loses its plasticity and becomes more or less friable. In the second stage consolidation takes place, the mass increasing in hardness until a stony texture is obtained. These two stages are respectively distinguished as "setting" and "hardening."

It follows from the complex character of its composition, that the reactions involved in the setting and hardening of Portland cement are themselves complex. It seems probable, however, that the reactions of setting involve the formation of super-saturated solutions and the deposition therefrom of close-knitted, interlacing crystals of various substances, while the slower reactions of hardening consist partly in the formation of similar interlacing crystalline products, but more especially in the production of a colloidal glue, which is, probably colloidal calcium hydrosilicate, and its gradual desiccation.

The colloidal interpretation of the hardening of cements is due to Dr. Wm. Michaelis, Sr., who reasoned that a pure crystallization process, as in the case of plaster of paris, can never cause hydraulic hardening, for a conglomerate of crystals, however insoluble, cannot produce impermeability, since crystals have plane surfaces with voids between them which would admit water. On the other hand, hardened cement mortars are impermeable, so that crystallization alone could not confer on them their valuable properties. Dr. Michaelis found the medium responsible to be the colloidal silicates formed in the later stages of hydration.

Illustrative of such structures and also of the primary crystalline formations which have been indicated as being responsible for initial set, in Fig. 4 is shown a surface found in a concrete 34 years old, taken from a dock wall in New York harbor. The production of these crystals was quite unlooked for, being due to an unusually delicate etching of the piece of clinker after polishing. It should be remembered that this magnification is high (200 diameters) and that these crystals are formed on a single particle. Multiply such interlacing formations a few million times for each cu. yd. of concrete, and it might be expected that a very considerable degree of mechanical strength, quite comparable to the strength of initial set, would be developed. This particular crystalline formation is shown tentatively, however, in this connection, as its identity with those chemical compounds known to be responsible for initial set is as yet conjectural.

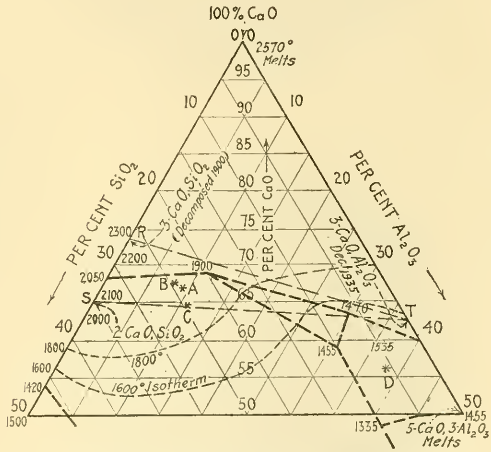


Fig. 2 Portion of Three Component Diagrams showing Products Formed by the Sintering of Varying Proportions of Portland Cement Constituents

But since this attack on the problems of hydration is primarily engineering, rather than chemical, and must therefore necessarily be identified with a study of actual concretes, it becomes necessary to make sure that there is a proper understanding of the internal structure of concretes and of the relative size, position in the mass and importance of the several constituents.

In Fig. 5 is shown a sectioned concrete specimen, weighing about ten lb. and about 8-in. × 6-in. × 1.5-in. size. It should be noted that none of the aggregate, whether large or small, so far as they are here visible, are touching at any point; rather, they are widely dispersed. But void determinations on this stone were made when the pieces were in at least point contact. Evidently, the voids must have been increased enormously by this dispersion; and if similar dispersion obtains for the finer materials as well, it is no wonder that proportioning concretes on the basis of void determinations has become discredited.

In Fig. 6 is shown a section of the same surface, but at twice the magnification, in order that the finer materials may be made visible. So far as they can be seen, this same dispersion obtains. Carrying the magnification to four times

Fig. 3

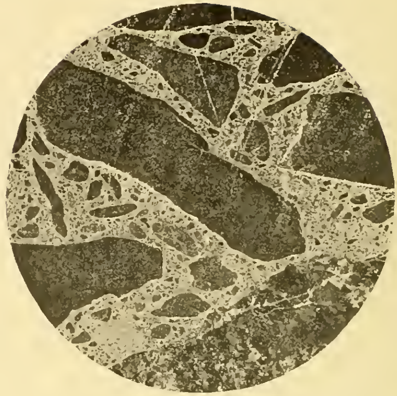

Fig. 6

Fig. 4

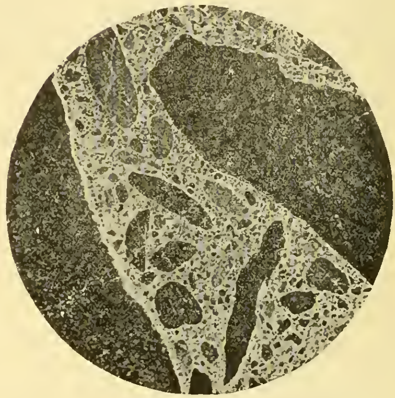

Fig. 7

Fig. 5

Fig. 8

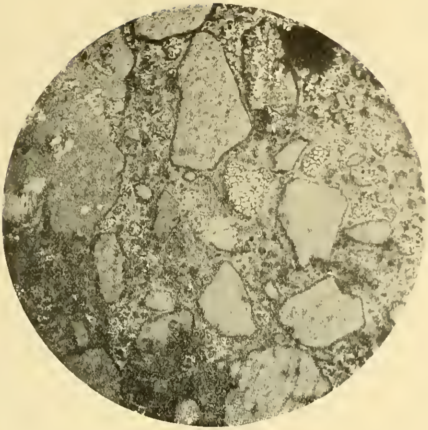

Fig. 9

Fig. 10

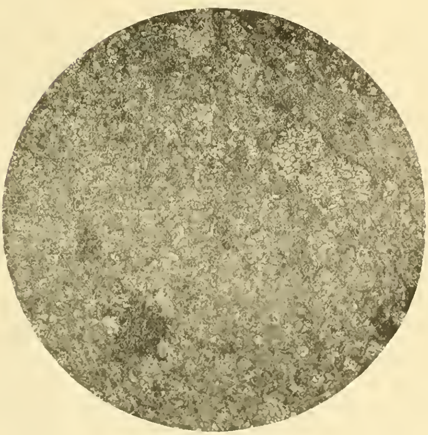

Fig. 11

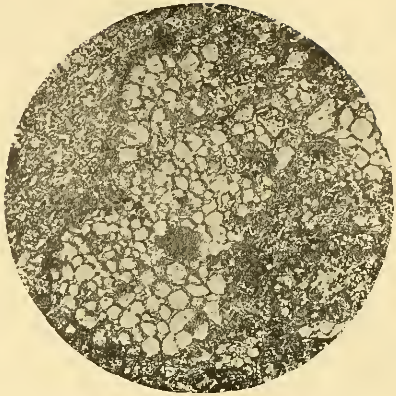

Fig. 12

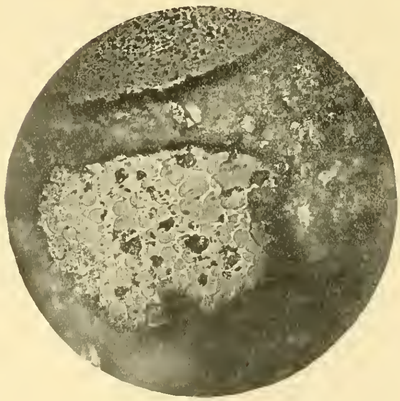

Fig. 13

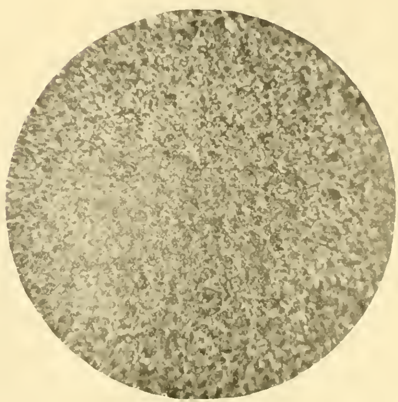

Fig. 14

the original, as in Fig. 7, this is made even more apparent; carrying it to 20 times the original, by means of photographing through the microscope, shows, as in Fig. 8, that all the aggregate in sight are sand grains of greater or less size, separated, as were the pieces of stone, and with still finer particles, too small to be sand, lying between them. Magnifying this same field to 60 times the actual diameter, as in Fig. 9, shows the sand grains in increased size, with a relative increase in their mutual dispersion; and a peculiar honeycomb structure on the smaller particles lying between them. Magnifying a portion of this same field 200 times, as in Fig. 10, this honeycomb structure is revealed more definitely. Since elimination of stone and sand from the known composition of the concrete indicates this honeycombed particle to be unhydrated cement and as similar formations occur profusely throughout all concretes, it becomes important to identify them beyond question and to study their functions in the rigid concrete mass, for, if they are unhydrated cement, lying inert, they have a most important bearing on the strengths of concrete.

The easiest identification is offered by comparison between the known and unknown material. In Fig. 11 is shown the structure of a neat cement briquette as viewed through the microscope at a magnification of 60 diameters. Comparing this with Fig. 9, which has the same degree of magnification, the identity of the two materials is strongly indicated. But to make this more certain, in Fig. 12 is shown the central portion of Fig. 11 but at a magnification of 200 diameters. Comparing this with Fig. 10, which shows the unknown material found in the concrete, their general characteristics are seen to be identical.

In an early paragraph of this paper, the proportion of material in standard sand mortar, which was then stated to be unhydrated cement, was seen to be large. In view of what has just been demonstrated, the truth of this statement is not difficult of proof. In Fig. 13 is shown a section of surface of a standard sand briquette, photographed at a magnification of 200 diameters. The structure of the cement group is here shown in an increased size, with the segmental edges of grains of standard sand, in its near neighborhood. Since in this briquette no materials other than cement, standard sand and water were used, the photograph serves as further proof of the identity of the questioned structure.

It may be objected, however, that this particle is too large to be a cement particle, and that if it were a group of cement particles, they would hydrate and fall apart. To answer this objection, recourse must be had to a consideration of the physical actions involved in wetting dry cement with water.

In Fig. 14 is shown at a magnification of 30 diameters the appearance of dry cement as it lies on a microscope slide. This cement film is very thin, a mere surface dust, but it will be seen that the distribution is very uniform. But if water is added, quite different conditions obtain. In Fig. 15, the water may be seen progressing across the field. Where the water is, there is not, as might be expected, a uniform wetting of the dry powder, but instead, the fine material is grouped in masses of varying size, and it is plain that some extraneous force would be required to break up these masses, since they evidently are in their present positions in obedience to the action of certain forces which have moved the particles from their original place.

The truth of this is easily demonstrable. Surface tension—that peculiar chain of action and interaction which causes rain drops to assume the spherical form—gathers the particles together in groups; and the finer they are, the more easily are they affected. The fineness of cement particles is, in this respect, a detriment to efficient hydration.

But in the process of this grouping, the particles have become slightly wetted. This has immediately resulted in reactions with the cement; and as the quantity of water is necessarily limited by the close grouping of these fine particles, a saturated solution between them, with deposition therefrom of the interlacing crystals before noted, has speedily resulted. In far shorter time, therefore, than is required for initial set under usual conditions, these little groups of particles have become consolidated; and unless the mechanical agitation of mixing is sufficient to break down this crystalline bond, they will remain unhydrated, save at their outer surfaces, so long as the concrete endures. This condition of affairs is difficult to overcome, even by the mechanical action of mixing, as the very small size of the groups renders unlikely their physical dispersion by the agitation of relatively large materials such as sand or stone, which by reason of the water present, are out of contact with one another. This is partially true regardless of the extent to which the process is prolonged. Further, the bond between these particles is speedily rendered more secure by secondary colloidal formations, with their desiccation by absorption of water by the interior of the mass. These colloidal boundary and bonding masses form the honeycomb structure seen in the photograph. Their appearance as white boundaries in some slides and dark boundaries in others is due to the method of polish-attack used in developing the surface prior to its examination.

This grouping and quick-cementing action, therefore, is the reason that the experimental apparatus developed proved inadequate for the task. This is particularly true of later forms, for in them the number of atomizing jets was increased to such an extent that the fine drops, though initially of a size suited to an individual cement particle, were in such numbers as to coalesce; and the larger drops thus formed caused, by surface tension, grouping of cement particles, such as has been shown. It is evident that means other than those at first proposed are required to produce effective hydration.

With a view to ascertaining the results produced by field conditions, as distinguished from the laboratory-made specimens which have thus far been examined, sections of a few concretes obtained from actual construction were examined. A large number of specimens of concretes were collected from representative structures throughout the world; and the author desires to take the opportunity here presented of extending personal thanks to the many engineers who have been so kind as to supply the samples asked for. Without their aid, the scope of this research would have been much restricted.

Examination of these specimens shows that similar conditions exist throughout the entire mass of each and since none of the specimens is over 1 cu. in. in volume, the quantity of cement remaining unhydrated through such grouping in each cu. yd. of concrete is a matter to ponder upon. It is easy to extend like illustrations to a far greater length with the data already at hand, but the series above given, covers a wide range of classes of concrete of varying ages

and conditions of service, and made under widely different conditions. *Grouping of particles in the manner indicated is a characteristic of all concretes so far examined;* and because of this grouping and of actions next to be indicated, it seems probable that only a small percentage of the cement added to concrete is effectively used.

Obviously, it is of the greatest importance that this grouping and isolation of large masses should be prevented. But even if this were quite perfectly done, there remain other actions which militate against thoroughly efficient hydration.

In microscopic examination of concretes, one of the most notable features of the hydrated matrix, aside from the large masses remaining unhydrated, is a "mealy" or speckled appearance. An example of this is shown at 60 diameters in Fig. 16 (concrete from pile caps underwater, Staten Island Ferry, Battery Park, New York). Such a surface is very difficult to photograph and was obtained only by the most delicate polishing. The mealy, or spotty, appearance is here clearly shown, and by careful examination, it can be determined that each of these spots is a cement particle, covered over with a colloidal, or perhaps a colloidal-and-crystalline skin, but remaining quite unhydrated at its center.

The reasons for these conditions are made clear by a consideration of the phenomena of hydration as before given, together with the absorption of water by the particle as hydration proceeds and the formation of an impermeable covering by the desiccation of this colloid through abstraction of water from the outer layers by the inner. Further, even with free access of water to the outside of a particle these conditions obtain, for in an agitated mass of cement in spite of the profuse formation of flocculent colloids, an unhydrated center has yet been found in each of the particles examined.

Therefore, it is evident that the finer the grinding, the better will be the hydration, as the finer the particle, the greater its surface in proportion to its bulk and in consequence, the more ready the penetration of reactive water. On the other hand, the finer the particles, the more ready and the closer will be their grouping by surface tension of the mixing water unless means can be found to lower this surface tension, without harmfully affecting the quality or the cost of the concrete.

The importance of increasing hydration cannot be exaggerated. Even a slight increase in thickness of hydrated layer results in notable increase in strength. In the earlier, though limited, investigations of this research when cement was delivered by an air-boil, to be met by finely atomized water under the best conditions for union, tensile and compressive strengths rose to high values, with a further peculiarity that the cement showed no retrogression with passage of time. Micro-sections also confirmed physical tests as to the progress of hydration, so that high hopes were entertained for commercial success along similar lines.

But since the conditions revealed by this research have become known and their causes have been ascertained, the next step is the overcoming of objectionable features by removing the causes of their origin. In other words, if high surface tension is at fault, to promote hydration lower that factor to a value which will not be disadvantageous. There are several substances which will lower the surface tension of water. One of these is alcohol, and the effect of additions of alcohol to the mixing water of cement may be readily investigated with the assistance of the microscope.

In Fig. 17 is shown the effect of adding water to this cement. As can readily be seen, the particles have grouped themselves in aggregations of varying size, in formations similar to those found in the examination of set concretes. But if to this water is added a small percentage of alcohol, dispersion immediately results, as in Fig. 18. Although the dispersion here is not complete, the cement is in vastly better situation to be effectively hydrated than it was when closely grouped, before the deflocculent (alcohol) was added.

In commercial work it is of course impracticable to use alcohol in sufficient quantities to properly promote hydration, nor would its use be beneficial to the concrete, because of the excessive liquid content thus made necessary to allow for the evaporation of the alcohol. But there are other agents even more efficient, which are cheap and easy to use and have no objectionable chemical action. So far as experiments have been carried out, these substances promise to produce concrete of greater density and strength than has heretofore been possible.

There are, however, certain other ordinary though important factors in the making of concrete which may be considered briefly. These are: *a* thorough mixing; *b* proper proportioning of aggregates; *c* proper consistency.

Thorough mixing is one of the most potent factors in securing thorough distribution of cement, thorough contact of cement paste with aggregate, and also, to a certain extent, hydration. Water does not necessarily wet aggregates instantly, for a reluctance or "skin effect" retards its passage over the surfaces of dissimilar materials. Further, this film of water on a piece of stone, for instance, or a particle of sand, holds beneath it air bubbles, which may in some instances be so numerous as to constitute an entire air-skin about the particle of aggregate, preventing contact between the cement and the sand or stone, unless mechanical agitation, with scraping by adjacent particles, is prolonged for a time sufficient to break down such films. Further, besides the smaller lumps and groups of cement particles caused by surface tension, there are commonly very large lumps of compacted cement in the sacks, and it often requires as much agitation to pulverize these lumps as it does to distribute the finer portions throughout the mix. A poor quality of concrete should not always be considered due to the cement, the aggregate or the water used, unless it is certain that proper mixing has been secured.

The proper selection and proportioning of aggregates is also of great importance. It has been pointed out above that void determinations were quite unreliable as a basis of proportioning, since the aggregates in the set concretes are all in far more dispersed positions, relative to one another, than they were when void tests were made. It is axiomatic that a concrete, which in density most nearly approaches the density of its large aggregate, is the strongest and best. Further, the smaller the amount of cement in a concrete, consistent with proper void-filling and proper bonding of aggregates, the better should be the concrete, since cement is the weakest of all the ingredients. For any given materials therefore the proportions should be determined in such ratio that maximum density will result, and if these proportions are adhered to in the field, a very superior concrete should be produced.

The question of consistency of mix is one which is closely related to the size and grading of aggregates. Obviously, a

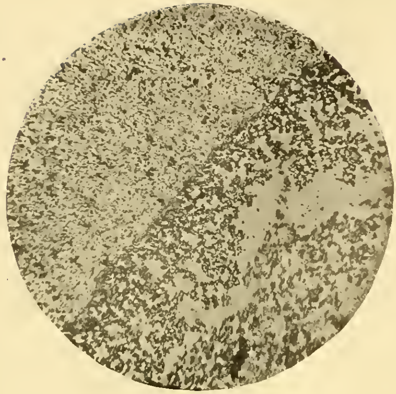

Fig. 15

Fig. 16

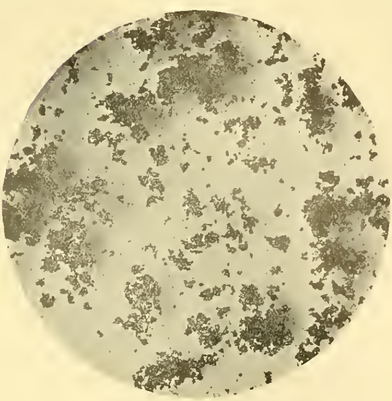

Fig. 17

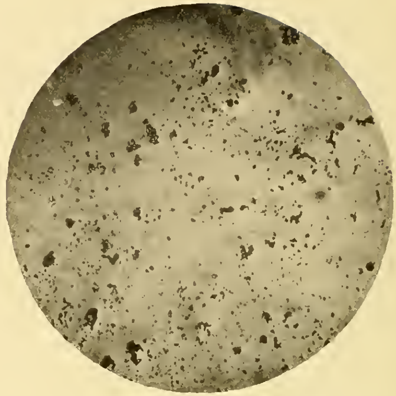

Fig. 18

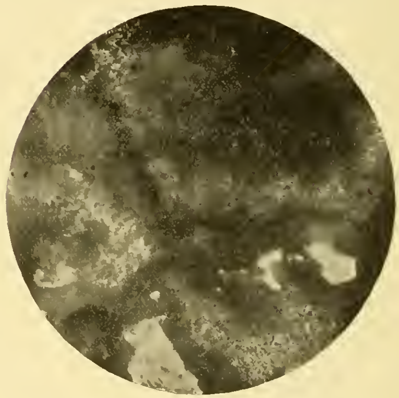

Fig. 19

Fig. 20


Fig. 21

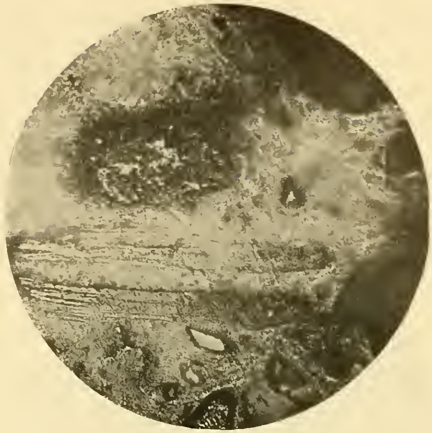
Fig. 24

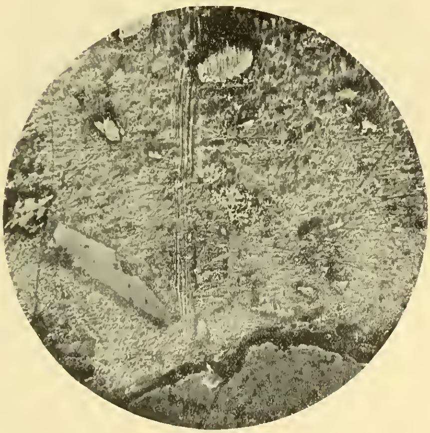
Fig. 22

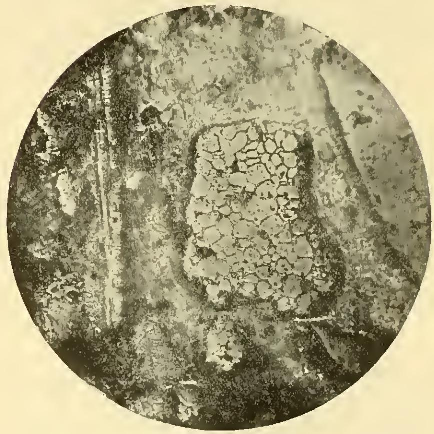
Fig. 25


Fig. 23


Fig. 26

fine sand, which has greater surface area than a coarse sand, will require more water for a given consistency of mortar than would the latter. Similarly a graded sand having less voids will require less water than would sand in which all the particles are of one size, and the same remarks apply to the larger aggregate as well. Excessive water may further occasion shrinkage cracks in the matrix. Some of these may be so large as to be visible to the naked eye, but others whose existence is rarely suspected are renderd visible only by microscopic examination. Fig. 19 shows a three-branched shrinkage crack of this kind. If proper tests of materials are made, the correct proportion of water may be determined, as well as the proportions of the ingredients; and if proper supervision is maintained in the field so that these quantities are adhered to, there need be little fear of producing a concrete which will develop faults as it dries, of "drowning" the cement, or of failure properly to fill forms, or to bond with the steel. Eternal vigilance in these details is one of the requirements for success.

Fig. 27

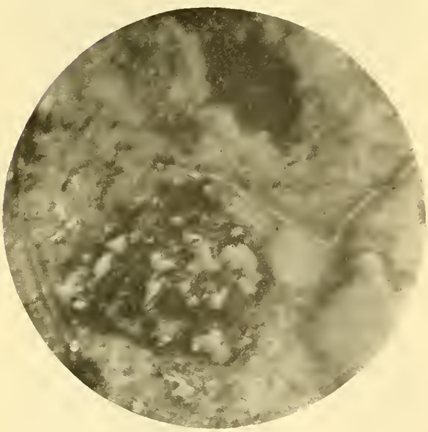

Fig. 28

There have been in the past certain cases of failure of concretes exposed to sea-water, which have become very widely known. It is probable that to no one phase of the concrete industry has so much thought and labor been devoted as to the study of the behavior of concretes in sea-water and the production of a cement capable of withstanding their action. There is considerable disagreement among authorities as to the causes of such disintegration, but there seems to be concurrence in the opinion that the formation of calcium sulpho-aluminate by interaction between the sulphates of sea-water and the aluminates of the cement, is in large measure responsible. This salt (calcium sulpho-aluminate) increases largely in bulk by crystallization and disrupts the concrete by the physical actions attendant thereon.

Fig. 29

If we were to picture mentally the formation of such an expansive material in the cement matrix of a set concrete, we should have to imagine a gradual straining of the material confining the crystals until rupture occurred. It is significant as to the correctness of such an hypothesis, that in the matrix of concretes which show outward signs of disintegration are found by microscopic study interior evidences of such strain.

In babbitts and the softer bronzes, incipient fracture is indicated by "shear planes" or "slip bands." In Fig. 20 at 150 diameters are shown similar "shear planes" in the cement matrix of a sea-water concrete taken from New York Harbor. It will be observed that these shear planes are at right angles to the polish-scratches on the specimen, so that their lack of identity cannot be questioned. Further, this is not an isolated case, since the same characteristic features are found in many other specimens taken from concretes in similar situations. Fig. 21 shows a repetition of these general features, as do also Figs. 22 and 23 all at 150 diameters. Other examples of the same structures could be readily furnished, but these four should be sufficient to establish the fact of their nature and existence.

Various stages of such crystalline disruptions, indicative at least of the possibility of such action, are detected by further micro-examination. In Fig. 24 at 200 diameters are seen a pair of parallel shear planes which have evidently progressed beyond the stage of strain and become actual fractures filled with crystalline material, as may be determined by their having withstood the abrasive action of the polishing powders, which cut away the softer matrix surrounding, leaving these fillings in high relief. In Fig. 25 at 200 diameters is shown a similar formation, with a large group of unhydrated cement particles near by. Fig. 26 shows at 150 diameters a similar conjunction of crystalline filling of slip planes and an unhydrated group. Whether or not this conjunction is of significance is a point yet to be fully determined.

Under certain conditions also this crystalline disruptive action may affect a considerable area. In Fig. 27 is shown at a magnification of 60 diameters part of such an extended action, where the crystalline formation is a long, disruptive dike. This structure resolved at higher magnification (200 diameters) is shown in Figs. 28 and 29, and this particular dike is of special interest in that it lies in a sample of a fresh-water concrete 12 years old, which is now showing pronounced outward signs of disintegration. It is greatly to be regretted that these dikes are so minute as to render their isolation and chemical analysis almost impossible. Such an analysis would be of great value in deciding many questions which at present seem to defy solution.

But whether or not calcium sulpho-aluminate is the major factor in disruptive formations in concrete, there seems to be agreement among cement experts that advantageous changes could be made in the chemical composition of cements, especially where they are to be used for sea-water concrete. A reduction in the alumina content would be beneficial in this respect, though it would entail serious difficulties in manufacture due to the higher temperatures required in burning the clinker. The addition in grinding of pozzolaine material, in order to obtain silica in a condition chemically available for union with the calcium hydrate liberated in the setting reactions, seems also to have much to recommend it. This latter change we should expect to prove very beneficial, for the leaching of calcium hydrate from cement structures which are subjected to the percolation of water is well known. Any such removal of material must necessarily leave a corresponding void suited to the reception of perhaps deleterious crystalline material, such as forms the dikes above noted.

There has recently been published a very exhaustive research, by Rankine and Shepherd[1] of the Geophysical Laboratory at Washington, on the products formed by the sintering of varying proportions of the three radicals, CaO, $Al_2O_3$ and $SiO_2$, which are the essential constituents of Portland cement. A portion of this three-component diagram, taken from the Rankine and Shepherd diagram and sketched with approximate correctness, is shown in Fig. 2.

In interpreting this diagram it should be noted that the lime content increases vertically, the percentage being read on the parallel horizontal lines. The percentage of alumina ($Al_2O_3$) increases downward at the right, the alumina content being read on the lines slanting downward from right to left. The silica content similarly increases downward but at the left, the percentage of silica for any mixture being read on the lines sloping from right to left. The heavy dotted lines indicate the loci of eutectic mixture, and the light dotted lines the approximate isotherms. It is evident from these that as the mixture under fusion changes its proportion of any of the three ingredients, the sintering temperature also changes; and, conversely, if the constitution of any mixture is known, the temperature required for its formation may also be determined.

For instance, the temperature commonly employed in burning Portland cement is in the neighborhood of 1500 deg. cent. This would be the proper sintering temperature of a mixture somewhere in the neighborhood of *D*, where the composition called for would be approximately 37.5 per cent of alumina, 6.5 per cent of silica and 56 per cent of lime. But the region of Portland cements is in the neighborhood of the point *A*, at which the indicated proportions would be alumina 9.66 per cent, silica 23.41 per cent and lime 66.93 per cent. For the proper formation of this latter compound a temperature of about 1900 deg. cent. would be required. As 1600 deg. cent. is the melting temperature of steel, and 1500 deg. cent. the usual kiln temperature, it is evident that in the burning of Portland cement, the natural tendency is to obtain a product unduly rich in alumina and low in silica and lime, so that the formation of the proper compounds is left largely to chance; and oftentimes unduly large proportions of $Al_2O_3$ are carried over, which, as was before noted, is generally held to be responsible for such disintegration of sea-water concretes as has been observed. This is a phase of the sea-water question in the solving of which the user can do little except demand a material of the quality he desires. Cement manufacturers are, however, caring for this question as adequately as commercial conditions will permit.

The above diagram, which is based on the tertiary alloy diagram of the late Dr. R. H. Thurston, is due to Prof. George B. Upton, of Sibley College, Cornell University. To him also is due the interesting transformation of chemical equations by reduction of certain elements to simpler equivalents, which does much to clear away the fog caused by the complex composition of cements and which further shows, by the same means, that the various cements, whether Portland, natural or iron-ore-Portland, have essentially the same actions as the basis of their setting properties. The location of these cements on the diagram are shown at *A* for standard Portland, *B* for the iron-ore-Portland used in the Panama Canal, and *C* for an American natural cement.

## DISCUSSION

John R. Freeman considered the paper, while excellently setting forth advanced methods in microscopic analysis of Portland cement mortar, gave simply a diagnosis of some of the most important diseases to which cement work is subject, without yet giving the remedy.

He looked upon the matter of applying the methods of micro-petography and micro-metallurgy to concrete as nothing less than epoch-making and considered that the recent studies made by the author and by certain other microscopists gave great promise of extremely important benefits. Yet so far as these studies were reported, he regarded them merely as an excellent beginning of a more precise, profound and intimate study of this most important building material, which should be encouraged by engineers and by cement manufacturers and carried very much further.

This paper considers chiefly the methods of microscopic

[1] Am. Journal of Science, Jan., 1914.

study of voids and lack of hydration. Another investigator has made a good beginning on studies of a soluble content of the cement, but it is no less important that the study should be continued into the realms of micro-physics and colloidal-chemistry, if one would learn the cause of some of the occasional serious failures in the strength of concrete and its slow disintegration by water and frost.

He had no doubt that ten years from now following studies of this kind, a better grade of concrete would be made and that some cement made by recent rapid and cheap methods and acceptable under present standard specifications would come to be regarded as doubtful if not dangerous, for portland cement is by no means a simple uniform material and different brands and perhaps different batches of the same brand are far from being alike and perhaps differ in very important particulars from the cement made ten, twenty or fifty years ago with which the reputation of Portland cement as a permanent water-resisting and frost-resisting material was established.

He recalled the great change that had come about within his experience of the past thirty or forty years in mixing and depositing Portland cement concrete; that the standard methods of distributing and depositing concrete in a sloppy condition which are standard today would not have been tolerated by any respectable engineer years ago in the days when standard practice was that of mixing concrete by shovels on a mortar bed, turning it over two or three times and depositing it in a mealy, slightly moist condition in thin layers and carefully ramming it until water flushed to its surface. Today the mixing by rotary machines surely is far more thorough and better than the old hand-mixing and this improvement doubtless more than compensates for the possible injury from excess of water in the modern method as compared with the old.

While nearly everyone knows of this great change in methods of mixing and depositing concrete, there are not many who fully appreciate the great change that has taken place within the past few years in methods of making cement in virtually a single operation under intense heat in rotary kilns, and we cannot yet be sure that the cement concrete put down today will all of it prove as durable as most of that made with the old-fashioned cement and deposited by the old-fashioned methods.

Microscopical studies like those presented in this paper will do much toward finding out how to improve the character of the cement and how to improve the quality of concrete, and today give more promise than any other line of investigation, but the studies must be carried much beyond the scope of those outlined in the present paper and the most refined processes of physical chemistry called in to aid.

The speaker suggested two matters of special importance which needed further study:

(1) That of the possible solubility of some of the ultimate compounds resulting from the setting of the modern cements, whereby structures having thin sections would in course of time lose much of the strength on which their integrity depends.

(2) The effect of obscure chemical properties in good-looking sand which might seriously affect the strength of the mortar.

To illustrate these matters he cited a few tests made, incidental to other work, in the laboratory of the New York Board of Water Supply and which suggested this danger of dissolving out and loss of the strength-giving quality in thin sections of concrete of somewhat pervious or lean quality. These tests were a few made primarily to determine whether or not aggregates containing certain varieties of limestone were soluble, but in the series were specimens made up for control purposes with aggregates essentially insoluble. Croton water under about 40 pounds pressure was made to percolate very slowly through disks some 4 or 5 in. in diameter by 10 or 12 in. broad for a number of months and the filtrate caught and subjected to chemical analysis, with the result that it appeared that more of the cement than of the aggregate was being dissolved. At the close of this test a few of the disks were tested for compressive strength with the surprising result that they possessed, as the speaker remembered it, less than one-fourth of the strength of similar disks which had not been subjected to this slow percolation. These experiments were not followed up because of lack of time and pressure of other work, but they give much food for thought, and it would seem that, after all this percolation, the cement in these specimens must have been hydrated and thus free from one important defect found by the author in most of his specimens.

The speaker recently has been shown the results of an investigation of disintegration of concrete which seemed to clearly indicate that the cement was partially dissolved out near the surface after a few years exposure to water and that the action of frost on the slightly porous mass remaining caused its breaking down.

Upon the second topic, of obscure chemical properties, and as illustrating the need of supplementing the microscopic studies by some researches in colloidal chemistry or by researches advanced into the realms of physical chemistry, he cited some troubles that he encountered three or four years ago when planning a concrete dam. Close to the site he found what seemed to be a perfect mixture of gravel and sand, well graded and apparently clean and requiring simply to be mixed with cement and water in order to give excellent concrete, but on sending samples of this material to the laboratory for mechanical analysis and test of mortar it was found that the mortar made from this sand would not stand up sufficiently to be held in the clamps of a testing machine after setting 7 days, and after setting for 28 days it gave a strength less than one-fifth of the normal when tested with four or five different brands of cement; yet one particular brand of cement was found which gave a fairly strong mortar with this same sand, thus proving that the trouble was to be looked for in the sand rather than in the cement, but no reason has yet been found why this one particular make of cement worked so very differently with this peculiar sand.

After washing this sand in a way intended to cause mutual attrition and scrubbing of the individual grains, it was found to give tolerably strong mortar with all these brands of cement, and on analyzing the wash water by methods used for drinking water the reports showed a large percentage of albuminoid ammonia. An expert of the U. S. Department of Agriculture, who had spent much time on studies of the solubility of the mineral ingredients of different soils, suggested to the speaker that the peculiar behavior of this sand in relation to Portland cement was probably due to a low, complex organic acid, akin to tannic acid, which was present in a condition of *adsorption* on the outside of the sand grains and that to find out what was

worth knowing about this action might keep a skilled research chemist busy for a year.[1]

It is certain that some concrete has withstood frost and the wear of rapid currents of water for many years marvelously well. On the other hand, it is certain that some concrete from cement made by rapid modern methods, under rigid specifications and conscientious inspections, has gone to pieces in a most distressing way. It is possible that some of the modern concrete put down with a super-abundance of water, and perhaps some that is made with cement containing ingredients leading to compounds that will ultimately become soluble, may bring disaster when concrete is used in thin sections under high water pressure and expected to retain its normal strength indefinitely.

The subject is extremely important and engineers should be grateful for all contributions to it like the present paper and should be pleased to note that while the author now simply gives his method of diagnosis, he implies that in a future paper a remedy for some of the present troubles will be presented.

Frank B. Gilbreth said that his first experience with Portland cement was in 1885, when cement practice was entirely different (from a workman's standpoint) from what it is to-day. In those days any man that used Portland cement on the first set was considered an ignoramous; to-day any many that uses it on the second set is considered a fool.

This work on the chemistry of cement is of tremendous importance to the country. What we are going to do with cement in the next few years as compared with what we have done will be of tremendous value in the structural world.

He had specialized in concrete, not in the chemistry of it but in its utilization, and in the latter connection he gave some of his experiences.

He was once building a hotel in San Francisco, and the reinforced concrete columns and girders were built up to the second floor, and the rest of the building was proceeded with, but the concrete did not set—and had not done so for eight weeks. Forms were taken out in a few places to see whether air was required to dry it out, but without effect. Just as it seemed that the concrete work must all be taken down, the San Francisco earthquake occurred, and the day after the concrete was found to be set. Whether it happened that the earthquake caused the setting or no, the fact is exactly as stated.

We are not sure but the atoms that make up the molecules in concrete might possibly require a physical start to cause the material to set. Several times the setting of concrete that has been delayed has been known to be started by machinery being run in the vicinity, and it is well known that if air riveters are working on the forms of concrete when the latter is being poured, a quicker set is obtained than at another time.

F. H. Newell also related an experience in connection with concrete refusing to set. The Board of Engineers had set up some concrete work at a large expense to the Government, and then reported that the concrete did not set and must be taken out. By the time the report was issued, the piers which were officially condemned as worthless had set as hard as granite.

In reference to the fineness of the cement, he thought it is generally recognized that fine cement is so much better than coarse cement such as that which stays at the top of a 200 mesh sieve, and which has very little cementing value. Such cement ground up and passed through a 200 mesh sieve and made into little test pieces had been found to break at 600 lb. per sq. in.; reground, passed through the 200 mesh sieve and set up again, test pieces broke at perhaps 300 lb. per sq. in. Reground a third time and set up, pieces broke at about 200 lb. This illustrates the point that the regrinding of the cement, bringing the minute particles into immediate contact, enables it to set up again, and apparently indicates that we are not getting the full cementing value from our concrete as ordinarily used. He thought this point is one worthy of a good deal of investigation.

G. A. Rankin[1] (written): This paper is very interesting and instructive in so far as it gives a large amount of data on the mechanical hydration of Portland cement and the disintegration of concrete in sea water. The discussion of the components of cement CaO, $Al_2O_3$, $SiO_2$, $F_2O_3$ and MgO, is, however, open to criticism.

The statement that if the constitution of any mixture is known, the temperature required for its formation may also be determined, is not true. The temperatures given in Fig. 2 are temperatures of complete melting and not temperatures required for the formation of compounds. In fact, it cannot be said that there are any definite temperatures for the formation of the compounds which go to make up Portland cement, as the formation depends on the time of heating and the fineness of the raw material, as well as the temperature. If sufficient time is allowed, it is possible to form these compounds even at temperatures much below that at which melting begins in a given texture. In actual cement practice, however, the temperature of burning is sufficiently high so that a small amount of the clinker is melted. This is necessary, as a small amount of melted material acting as a flux is required in order that the formation of compounds may be completed within a reasonable time. The temperature of the clinkering zone as determined by the Geophysical Laboratory in a number of Portland cement kilns was found to be about 1425 deg. cent. At this temperature only a small portion of the clinker is fused (melted); even so, it is sufficient for the proper formation of the compounds if the raw material is of a fineness such as is ordinarily required in good cement practice; in other words, the reactions which take place in the burning of Portland cement clinker go practically to completion even at a temperature of about 1425 deg. cent. The statement that the formation of the proper compounds is left largely to chance and that oftentimes unduly large proportions of $Al_2O_3$ are carried over is not true of good cement practice. In such practice it is possible to so control the raw material and conditions of burning that the resulting cement will be made up of proper compounds in such proportions that no improperly combined $Al_2O_3$ will be present. As to whether or not it is the compounds of $Al_2O_3$ which react with sea-water to cause the disruption of concrete is another matter, which it should be possible to settle by determining the action of sea-water on cements made up of the two aluminates, $3CaO.Al_2O_3$, and $5CaO.3Al_2O_3$, which occur in Portland cement. The idea that CaO and MgO and likewise $Al_2O_3$ and $Fe_2O_3$ act similarly

[1] See Eng. News, July, 1912, contribution by J. R. F.

[1] Geophysical Laboratory, Washington, D. C.

in hydraulic cements and form similar chemical compounds is erroneous. Recent investigations have shown that MgO and CaO, likewise $Al_2O_3$ and $Fe_2O_3$ do not act chemically alike, either in the reactions which take place in the burning of cement or in those which take place during hydration. For example, CaO unites with $Al_2O_3$ in the formation of four distinct compounds, while MgO unites with $Al_2O_3$ to form but a single compound whose properties are not similar to the calcium aluminates. Again, $Fe_2O_3$ and $Al_2O_3$, as they occur in cement compounds, react with water very differently, the ferrates being slow to act while the aluminates react with great rapidity, and the final products of hydration have decidedly different properties. It will be seen, therefore, that speculation which assumes the reactions between the chemical components of Portland cement, based on any two or more of these components acting as chemical equivalents, may lead to disastrous results.

In order to establish a sound basis for the study of Portland cement and its use in concrete, it is absolutely necessary that one proceed systematically to determine first the components which make up the cement. These are CaO, $Al_2O_3$, $SiO_2$, Mgo, $Fe_2O_3$, etc.

Knowing the components, the next step is to determine by experiment the compounds formed by these components in the proportions as they occur in cement. Having isolated each of these compounds to determine its composition and its optical properties for its certain identification, it will then be necessary to study its hydraulic properties. With this data it will be possible to state definitely just what is the nature of the setting of cements, also to state just what compounds should be present in order to produce the strongest cement and what compounds are best to withstand action of seawater, etc.

Proceeding in this systematic way, work has been carried on at the Geophysical Laboratory in an effort to determine the compounds formed by the components which make up Portland cement clinker. Since the components CaO, $Al_2O_3$, $SiO_2$ make up over 90 per cent of the chemical composition of most Portland cement, it seemed best to first make a study of these three oxides by themselves. The result of this investigation has shown that when CaO, $Al_2O_3$, $SiO_2$, are burned in the proportions as they occur in Portland cement clinker, the resulting product is made up largely of the compounds $3CaO.SiO_2$; $2CaO.SiO_2$; $3CaO.Al_2O_3$, with occasionally small amounts of free CaO and the compound $CaO3Al_2O_3$. Each of these compounds has definite optical properties which have been determined; this enables one to identify these compounds in any mixture in which they may occur.

The cement clinker made up only of CaO, $Al_2O_3$, $SiO_2$ on grinding and mixing with water has been found to possess all the properties of a desirable Portland cement. It has furthermore been found by subsequent work of the Bureau of Standards at Pittsburgh, that over 90 per cent of an average Portland cement clinker is made up of $3CaO.SiO_2$; $2CaO.SiO_2$; $3CaO.Al_2O_3$; and $5CaO.3Al_2O_3$. These compounds are present as definite individual crystals whose optical characteristics are not appreciably affected by the small amount of MgO, $Fe_2O_3$, etc., which are always present in Portland cement. A study of the hydration of those compounds was undertaken by the Pittsburgh Laboratory of the Bureau of Standards, and from the results obtained it is now possible to explain the chemical reactions which take place during the setting of Portland cement. With these added data it is now possible to proceed with confidence to the determination of the proportions of these CaO, $Al_2O_3$, $SiO_2$ compounds which should be present in order to produce a cement which on setting will possess the most desirable properties for various purposes.

HARRY FRANKLIN PORTER[1] wrote that Mr. Johnson has established, by laboratory methods, conclusions which the writer believed since 1908, that the true cement is a colloid produced by thorough hydration. A special article dealing with this important subject, based largely on the findings of Dr. Michaelis, was inserted in an appendix to a publication by the writer the following year.

Further, at the 1910 convention of the American Concrete Institute, the writer again devoted a considerable portion of a paper to a discussion of this subject, recounting an experience in Philadelphia several years previous, in which the value of thorough mixing of concrete as promoting colloidal formation was conclusively demonstrated.

This experience was that a certain batch of concrete, supposedly useless on account of having been churned in the mixer during the whole of the noon hour, was dumped on concrete poured the previous day. Instead of becoming a loose mass of rock and sand, as expected, it set up smooth and hard and adhered so firmly to the old concrete as to require picking to remove it. Moreover, it presented a different appearance than any concrete the writer had seen before and was much more uniform in color and texture. The exceptionally thorough mixing, and the unintentional thorough hydration, instead of weakening it seemed to have vastly improved its quality.

In concrete work, there is necessity for, first, intelligent selection of the aggregates; second, their scientific proportioning; and third, their thorough admixture. If the proper care is taken in these matters, not only is a considerably less amount of cement sufficient, but a concrete of vastly superior quality and strength is secured.

THE AUTHOR. The comment most frequently met with in regard to this microscopic study of concretes is that it does not indicate a remedy for the defects shown. Microscopic examination is primarily a diagnosis. It shows concretes as they actually are, not as they are supposed to be; and the faults that careless procedure and improper selection of materials induce. Further, the inter-relation and the inter-action of the several materials composing concrete are made plain, together with the penalties attendant upon any neglect of these inter-relations.

The remedy lies very largely in alterations of our present procedure. It is very true that there are certain beneficial changes that might be made in the cement, which is not by any means an ideal product, but it is true, also, that more care should be used in the selection and particularly in the quantities of the other constituents used. When the concrete maker realizes that the quantities and gradings of his stone and especially of his sand are vitally important and when he also realizes that the quantity of water may not be varied beyond certain limits, we may hope to see a very important change in the quality of concrete.

It should also be realized by engineers that concrete is not an infinitely dense, hard, resistant substance, but that, on the contrary, it is a material which varies in durability.

[1] *Industrial Engineer*, Chicago, Ill.

# DESIGN OF RECTANGULAR CONCRETE BEAMS

BY HOWARD HARDING, ROCHESTER, N. Y.

Associate-Member

The resisting moment of a reinforced concrete beam, in inch-pounds, may be represented by the formula

$$\text{Resisting moment} = R\ b\ d^2$$

where

$b$ is the breadth of the beam in inches
$d$ is the effective depth in inches
$R$ is a numerical coefficient

The value of $R$ (for a given ratio of the modulus of elasticity of steel to that of concrete) depends upon the percentage of steel reinforcement used and the safe working stresses for steel and concrete. These values of $R$ for different working stresses and percentages of steel have been plotted in very

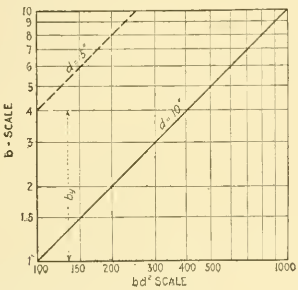


Fig. 1 Diagram for Checking Relations indicated by Equation

convenient curve form in Turneaure and Maurer's "Principles of Reinforced Concrete."

For the purposes of this article it will be necessary to cite only a few values of $R$ corresponding to some of the more common working stresses. The ratio of $E_s$ to $E_c$ is taken as 15.

For $f_c = 700$ and $f_s = 16{,}000$   $R = 120$, per cent steel $= 0.87$
For $f_c = 600$ and $f_s = 16{,}000$   $R = 94$, per cent steel $= 0.68$
For $f_c = 500$ and $f_s = 16{,}000$   $R = 71$, per cent steel $= 0.50$
For $f_c = 400$ and $f_s = 16{,}000$   $R = 49$, per cent steel $= 0.34$

In case of reinforcement in excess of the amount required to divide the working stresses as shown there is a slight gain in strength due to the shifting of the neutral axis toward the steel. When the concrete has reached its working stress the steel will still be understressed. In such cases the value of $R$ used must be the one corresponding to the working stress of concrete and the percentage of reinforcement.

The ordinary method of using the data thus given is that of "cut and try."

After quite a bit of experience with that method the growing dissatisfaction prompted the plotting of the equations involved so as to give a direct method of arriving at the result desired. After some study a logarithmic form was adopted which seems to serve the purpose.

On a sheet of logarithmic cross-section paper the values of $b$ were denoted by the horizontal lines intersecting the left-hand ordinate. The left-hand ordinate was called the $b$ scale. Through the origin (that is, through the point 1, 1 of the diagram) draw a line to the right at 45 deg. to the horizontal. By inspection of Fig. 1 it can readily be seen that the point of intersection of any value $b$ with the oblique line, if projected vertically upward to the top horizontal scale of the paper, will give a logarithmic reading exactly equivalent to that of the $b$ scale. Now let the oblique line correspond to $d = 10$ and multiply the readings of the top horizontal scale by 100. Then again by inspection, it will be seen that by projecting vertically upward the intersection of any value $b$ and the line $d = 10$, we may (on the multiplied horizontal scale) read directly the corresponding value of $b\ d^2$.

For values of $d$ other than 10 there is a family of lines parallel to the line $d = 10$.

It now remains to introduce the factor $R$ into the diagram. A range of from 40 to 120 for this coefficient will be found to cover about all cases likely to arise. Since the bending moment is ordinarily computed in foot-pounds we may write our fundamental formula to correspond to those units. Then

$$\text{Resisting moment} = R\frac{b\ d^2}{12}$$

and when $R = 120$

$$\text{Resisting moment} = 10\ b\ d^2$$

By projecting the values of the $b\ d^2$ scale upward to a horizontal scale whose readings are 10 times that of the $b\ d^2$ scale, we obtain directly the resisting moment in foot-pounds corresponding to any value of $b\ d^2$ and $R = 120$. The diagram is arranged to care for other values of $R$ by taking the proper fractional part of the resisting moment of the beam at $R = 120$. Thus, for $R = 60$, one half of the resisting moment of the beam at $R = 120$ is taken. This is done graphically by proceeding upward to the horizontal line representing the desired value of $R$ and thence proceeding along the oblique line to the top scale where the resisting moment in foot-pounds is read.

In the lower part of the diagram it will be noticed that there are two other families of oblique lines. One of these shows the ratio of $d$ to $b$ and the other the cross-sectional area or the product of $d$ times $b$.

The method of using the diagram is ordinarily just the reverse of the order in which it has been developed. First decide upon the working stresses and determine the corresponding value of $R$ and the percentage of reinforcement. Then compute the bending moment in foot-pounds which it is desired that the beam should withstand. Locate the bending moment thus computed at the top of the diagram, Fig. 2. Thence proceed parallel to the oblique lines until the value of $R$ previously determined is intersected. From this intersection proceed vertically downward into the lower part of the diagram intersecting the horizontal lines representing breadth, and the oblique lines representing depth. At any one of these intersections the required breadth and depth may be read. Any of the corresponding values will satisfy the condition for strength, but the values chosen will depend upon the shape of beam desired. If we wish a certain

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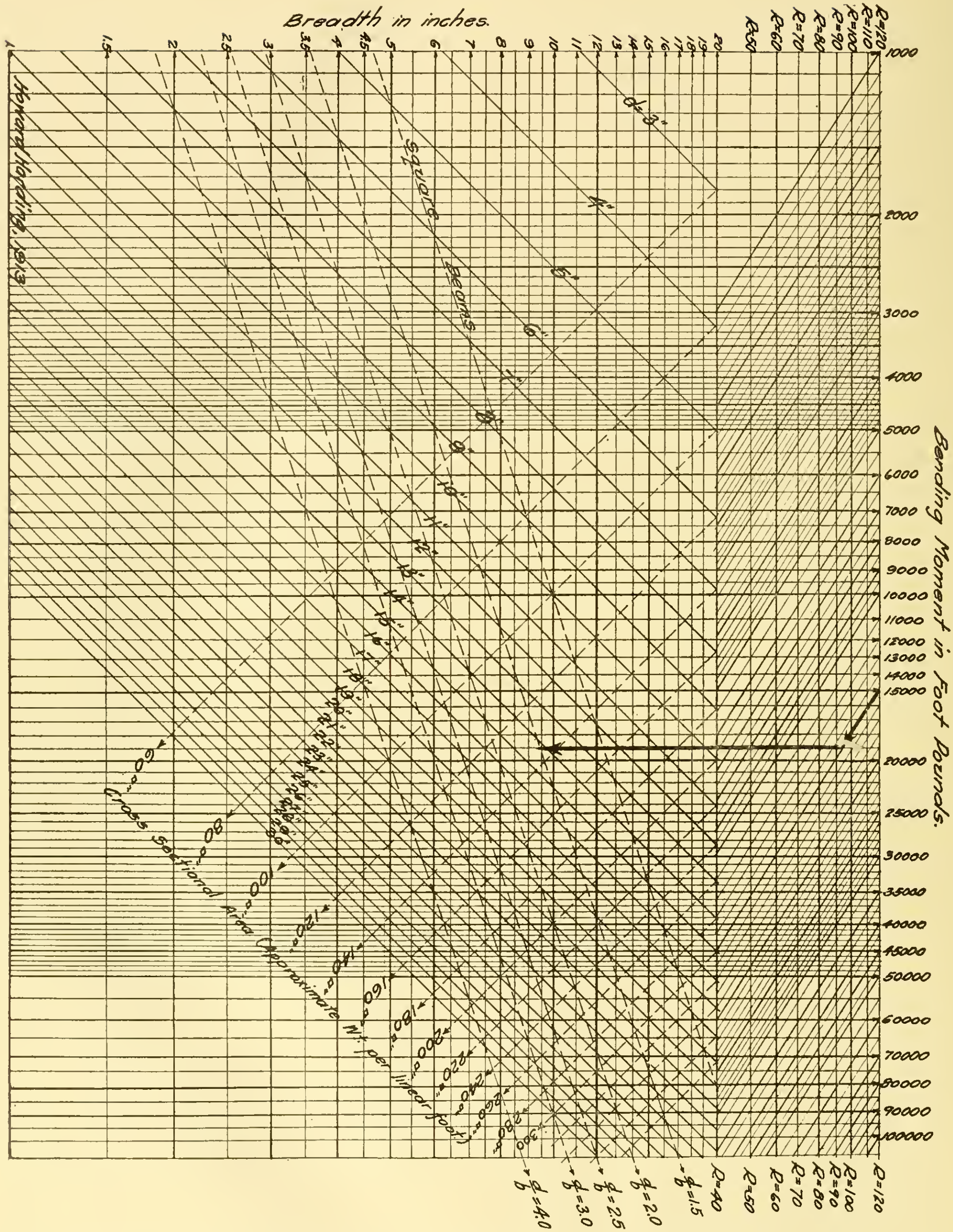


Fig. 2 Diagram for Graphically Determining the Resisting Moments of Reinforced Concrete Beams

ratio of depth to breadth we can obtain it by stopping at the dotted line representing that ratio. If a certain depth or a certain breadth is desired it is necessary to proceed vertically downward until said depth or breadth is intersected and the point of intersection automatically determines the value of the other dimension.

In a beam of dimensions as determined by the use of the diagram in Fig. 2 no allowance has been made for the bending moment of the beam due to its own dead weight. To take care of this additional bending moment either one or both of the dimensions must be increased. To determine the amount of the increase necessary for different spans and types of beams a second diagram has been developed. The strength of the beam may be increased in three different ways, viz; (*a*) by increasing both breadth and depth, (*b*) by increasing depth only, and (*c*) by increasing breadth only. The determination of multiplying factors for these three cases is now taken up.

The author derives the following formulae to cover these cases:

Increasing strength by increasing breadth and depth:

$$\left\{ \frac{(1.56\ k^2)}{k^3 - 1} \right\} l^2 = R\ d$$

Increasing strength by increasing depth only:

$$\left\{ \frac{(1.56\ k)}{k^2 - 1} \right\} l^2 = R\ d$$

Increasing strength by increasing breadth only:

$$\left\{ \frac{(1.56\ k)}{k - 1} \right\} l^2 = R\ d$$

It will be noted that the form of the three expressions just developed is the same, the only variation being in the exponent of the term $k$ enclosed in the parenthesis. A tabulation of the values of the parenthesis corresponding to different values of $k$ is given in the paper.

To summarize the foregoing it may be well to work out a problem in detail. The writer has found the following to be a very convenient and useful form of computation:

Girder $G_7$

Span = 18 ft. Load = 370 lb. per linear ft.

Bending moment $= \frac{w\,l^2}{8} = \frac{370 \times 18^2}{8} = 15{,}000$ ft-lb.

Shear = 3,330 lb. + ½ weight of beam

$f_s = 16{,}000$ $f_c = 600$ $R = 94\%$ steel = 0.68 sq. steel rods

| | | | |
|---|---|---|---|
| $b_1 \times d_1$ | 12.5×12.5 | 9.4×14.10 | 7.5×16 |
| Corrector | 1.17 | 1.145 | 1.136 |
| $b \times d$ | 14.6×14.6 | 10.8×16.1 | 8.5×18.2 |
| $b \times d$ | 213 | 133 | 120 |
| Unit shear | 25 | 35 | 37 |
| Steel | 4⅝-in. bars, or 3 11/16-in. bars | 3 9/16-in. bars, or 2 11/16-in. bars | 3 9/16-in. bars, or 2 11/16-in. bars |

The above tabulation shows three beams which would be suitable. The one which best suits the rest of the structural design may be used. The correction factor used was the one corresponding to the increase in both dimensions. It should be noted that $d$ represents the effective depth, and the distance from the steel reinforcing to the bottom of the beam must be added to get the total depth. This "cover" portion of the beam has been neglected in all of the computations for strength. The determination of the second beam in the tabulated form is plainly indicated on the diagrams so that the method of using them ought to be readily understood.

# MODEL EXPERIMENTS AND THE FORMS OF EMPIRICAL EQUATIONS

BY EDGAR BUCKINGHAM, WASHINGTON, D. C.

Member of the Society

THE purpose of the paper is to illustrate, by application to a few problems in technical physics, the methods by which dimensional reasoning may be made use of in planning and interpreting experiments, in devising empirical equations for use in design, and especially in the performance of experiments on models in such a way as to furnish reliable information about the full-sized originals.

*The General Theorem.* The well known principle of the dimensional homogeneity of physical equations may be expressed in the form of an algebraic theorem which is convenient for application. This will be referred to as "the Π-theorem": it states that any relation which involves $n$ physical quantities of different kinds, may be described by an equation of the form

$$f\ (\Pi_1, \Pi_2, \ldots \Pi_{n-k}) = 0,$$

in which $k$ is the number of fundamental units needed, and the Π's are dimensionless products of powers of the symbols which represent the various physical quantities involved in the relation. The value of $k$ is generally 3 in mechanical problems, though in statics $k = 2$. In the most general problems, involving thermal and electromagnetic, as well as mechanical quantities, $k = 5$.

To avoid delay at this point, the deduction of the Π theorem is relegated to an appendix.

*The Flow of Liquids in Smooth Pipes.* The mechanism of applying the Π-theorem in a concrete instance is illustrated in this familiar example, and it is shown that any correct equation for representing the flow of an incompressible fluid through a smooth pipe must be of the form

$$\frac{DG}{\rho S^2} = \phi\, \frac{DS\rho}{\mu}$$

in which: $D$ = diameter; $G$ = pressure gradient; $S$ = speed of flow; $\rho$ = density of the liquid; $\mu$ = viscosity of the liquid; and $\phi$ represents an unknown function of $\frac{DS\rho}{\mu}$ which must be determined empirically. Comparison with the best experimental data confirms the conclusion, and the plotting of a diagram, in which English and metric data are used indiscriminately and without conversion, illustrates the convenience of working with dimensionless quantities. The comparison of the above equation with the known facts helps us to a physical understanding of the phenomena of stream line and turbulent flow—especially the existence of a critical speed and the unimportance of temperature at high speeds or in large pipes.

*Resistance of Immersed Bodies at Moderate Speeds.* A "moderate" speed is one far enough below that of sound in the medium, that the compressibility of the medium has no sensible effect on the resistance encountered by a moving body. The Π-theorem is used in finding the necessary general form of empirical equations between the resistance, speed, size, and shape of the body, and the properties of the

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medium. Consideration of the general equation and of the experimental work needed for determining its specific form, leads to the notion of model experiments and to the conceptions of corresponding speeds and of dynamical similarity. This explains the justification of the method of determining data on air-ship forms by the use of very small scale models in water.

*Resistance to the Flight of Projectiles.* This section shows how the conclusions reached in the preceding one must be supplemented and modified when the speed approaches or surpasses that of sound and the resistance is increased by the continual drain of energy in maintaining the head and base waves. Model experiments in air are impracticable, but the interesting possibility suggests itself that information about the resistance of large projectiles might be obtained from observations on the retardation of very small models—to a scale of about $\frac{1}{60}$—shot under water. A plot of observed resistances in air shows that the resistance offered to high-speed projectiles depends on density and compressibility while the effect of viscosity is negligible.

*Screw Propellers.* The consideration of the thrust of screw propellers illustrates an application of the Π-theorem in a more advanced case, the number of kinds of quantities to be considered being greater than in the examples already treated. The conditions for dynamical similarity of propellers of the same shape but different diameters are found, the simplest being that the propellers shall be run at the same slip ratio and the same relative immersion. The conditions can not all be exactly satisfied in practice, but it is further shown how one of the conditions, that relating to viscosity, is of small importance, and how by neglecting it, approximate results may be obtained. The condition for corresponding speeds of advance is then the same as in Froude's law of comparison, and the thrusts are proportional to the cubes of the diameters. This conclusion appears to agree with experiment, showing that the approximation made in neglecting viscosity is permissible. If propellers of a given shape are run at the same slip ratio and so deeply immersed as to cause no surface disturbance, all speeds correspond, and the thrust is proportional to $(DS)^2$, $D$ being the diameter and $S$ the speed of advance.

*Heat Transmission.* The Π-theorem is applied to a simplified problem in heat transmission, and it is shown that while various roughly approximate relations must be assumed, the assumptions are plausible and the results obtained probably nearly correct for ordinary heat transmitting devices, such as steam coils with air forced over them for indirect heating, under working conditions. Some of the algebraic expedients which are occasionally needed in using the Π-theorem and which have not come up in any of the preceding sections, are illustrated here. The physical conclusion is that under ordinary working conditions, when a fluid is forced through a heating or cooling device of given design, the difference of temperature of the fluid and the solid surfaces at exit is a definite fraction of the difference at entrance, this fraction being fixed by the design of the apparatus and influenced in only a very minor way by the size of the apparatus, the initial difference of temperature, the nature of the fluid, or its rate of flow.

*Conclusion.* It is pointed out that the method of reasoning by means of dimensions is purely algebraic and therefore rigorous, so that the correctness of conclusion obtained by its aid depends only on how much physical knowledge and common sense we display in using it, the method itself being a mere logical tool. It is, however, extremely easy of application, and it often throws a quite surprising light on experimental facts which would, without its aid, be very difficult to analyze and interpret correctly.

## DISCUSSION

M. D. Hersey. The author has struck the keynote of a new development of technical physics, which will eventually play the same part in mechanical engineering that physical chemistry has begun to play in the chemical industries. It will directly be seen that this prediction is not a prophecy at all, but merely an observation.

The importance of technical physics, as a branch of subject matter, is already so clearly recognized in Germany that laboratories are being established exclusively devoted to this field.

But the development which I think we may now anticipate is something distinct from this, and a natural sequel to it: I refer to the development of technical physics, not as a branch of subject matter, but as a method of reasoning.

It is from such a standpoint that technical physics becomes analogous to physical chemistry which is the planning and interpretation of chemical experiments in the light of thermodynamics and the phase rule; and the Π-theorem is closely analogous to thermodynamics and the phase rule. Thermodynamics affords certain rigid connecting links between seemingly isolated experimental results, while the phase rule tells us the number of degrees of freedom of a chemical system. The Π-theorem likewise affords rigid connecting links which not only serve as a check on the consistency of our results, but may greatly cut down the labor of experimenting. Thus, on applying the Π-theorem to lubrication, we find, under certain conditions, that the coefficient of friction, $f$, must be some function or other of the *two* variables $\frac{\mu n}{p}$ and $\frac{D^3 n}{Q}$ alone; in which $\mu$ denotes viscosity, $n$ revolutions per unit time, $p$ bearing pressure, $D$ journal diameter, and $Q$ volume of oil pumped through bearing in unit time. Hence, the same change in $f$ will be produced by a given change in the argument $\frac{\mu n}{p}$, whether this change is, in turn, caused by varying $\mu$ in one direction or by varying $p$ in the other direction; and so on. These facts, all implicitly contained in the Π-theorem, can, for the sake of emphasizing our analogy, be expressed by the equations

$$\frac{\delta f}{\delta\mu/\mu} = -\frac{\delta f}{\delta p/p} \quad \text{whence} \quad \frac{\delta f}{\delta p} = -\frac{\mu}{p}\cdot\frac{\delta f}{\delta\mu};$$

$$\frac{\delta f}{\delta D^3/D^3} = -\frac{\delta f}{\delta Q/Q} \quad \text{whence} \quad \frac{\delta f}{\delta D} = -3\frac{Q}{D}\frac{\delta f}{\delta Q}\text{; etc.}$$

And, just as the phase rule tells us that the number of degrees of freedom in a chemical system is $F = K - P + 2$; $K$ being the number of components which coexist in phases; so also the Π-theorem tells us that the number of degrees of freedom in a physical system is $f = p - k - 1$; $k$ being the number of fundamental units needed to describe a relation subsisting among the $p$ physical quantities. The number of factors which must be experimentally varied in order to map out the relation for the first time is, of course, one

greater than the number of degrees of freedom, or simply $p-k$.

The author has himself stated that the paper contains nothing essentially new. Any allusion to the contrary would be an impediment to the successful use of the methods presented. The kernel of the paper is a theorem which is merely a restatement of the requirements of dimensional homogeneity, announced by Fourier nearly a hundred years ago, and extensively used by Rayleigh and others. But the fact that the paper contains nothing essentially new does not diminish its value. Gibbs' phase rule, too, was new only in form, not in substance, yet it served as the crystallizing influence which caused an immense number of latent ideas to fall into line, and we may expect the $\Pi$-theorem to play a similar role.

This inevitable development of technical physics into a unified branch of science, which will require the same fundamental place in the engineering curriculum that physical chemistry now holds in the chemical curriculum, can be facilitated if writers on the problems of hydro and aero dynamics, heat transmission and the like will be as introspective as possible, explicitly calling attention not only to their results, but to their methods of reasoning as well. For in every successful artifice of reasoning there must be some element which is universal, and capable of being generalized and made into a working tool.

In conclusion, the fact should be recorded that the writer's paper on the Laws of Lubrication is in part an application of the $\Pi$-theorem, and that, therefore, the discussion of his paper is to be considered a continuation of the discussion of Dr. Buckingham's paper.

Melach I. Nusim. The author calls attention to the aid to be obtained in the application of the theory of dimensions in scrutinizing results of tests, and his general methods should be of value to engineers engaged in experimental work.

The conditions for similarity, discussed in the paper, have been noted and applied with great advantage by designers of centrifugal compressors and pumps. Two centrifugal compressors, if they are geometrically similar, have the same efficiency provided the following relation is maintained between the rated flow, $Q$, the peripheral speed of the impeller, $S$, and the impeller diameter, $D$:

$$\frac{Q_1}{S_1D_1^2} = \frac{Q_2}{S_2D_2^2} = \text{constant.}$$

The experimental data on one particular size of compressor can be utilized to predict with accuracy the performance of a number of sets provided they are made geometrically similar and rated according to the relation mentioned above. In terms of the mean effective pressure, $P$, the r.p.m., $N$, and the flow, $Q$ (volume per unit of time), the relation is equivalent to

$$\frac{QN^2}{P^{\frac{3}{2}}} = \text{constant.}$$

A. R. Dodge said he had investigated the drop in pressure of superheated steam under similar conditions to those of Stanton and Pannell's experiments on air and water, using a 1-in. smooth drawn brass pipe, steam jacketed. The results obtained showed that the same formula for pressure drop would apply for steam, in addition to air, water and oil. It ought, therefore, to apply for any fluid and simplify existing formulae.

He had also made a number of steam tests with commercial iron pipe, 2 to 8 in. in diameter, and found that the results were consistent, being only modified by the roughness of the pipe.

John R. Freeman said that he possessed data of his own experiments with ordinary rough pipes, which might be of value in solving the problems presented. He said he had conducted a very extended range of experiments, in 1893, on pipes of all degrees of smoothness, from seamless brass pipe to exceedingly rough pipe.

L. W. Wallace asked for further information in connection with investigations to determine certain facts in reference to locomotive sparks. It becomes necessary to know to what height sparks are ejected from locomotives under various operating conditions, and he asked whether experiments with a specially designed model locomotive would give data that would be comparable with the actual height the sparks would be thrown, the size of the sparks, etc.

The Author. In reply to Mr. Wallace, it is conceivable that model experiments might be so devised as to furnish the desired information; the difficulties appear, at first sight, rather formidable. It is impossible to say off-hand, before examining the problem carefully, whether an attempt to solve it in this way would have any prospect of success. It would seem much simpler to study the actual emission of sparks from a locomotive by making runs at night and taking photographs—possibly kinematograph records—from two points on the train, one close to the locomotive and one much farther back.

In reply to Mr. Freeman, in trying to get an equation which could be made to represent the resistance of both smooth and rough pipes by varying only a single quantity—representing the roughness—the author had used Saph and Schoder's results exclusively, because in a preliminary study consistency was more important than accuracy. He had found, however, that the data were not sufficient for his purpose, and it would be a matter of great interest to him if he were privileged to examine Mr. Freeman's experimental results.

In reply to Mr. Dodge, it must be a satisfaction to all concerned with the subject of pipe resistance that the results of his wide experience with steam agrees so well with those obtained by Saph and Schoder for water, and by Stanton and Pannell for both water and air. We may safely conclude that the basis of physical ideas from which the dimensional treatment starts is sensibly correct and that no important element in the problem has been overlooked. The results obtained by dimensional reasoning are so instructive and the problem of pipe resistance so important that the confirmation which Mr. Dodge has given is a valuable contribution to the subject.

The example, brought forward by Mr. Nusim, of the practical utilization of the motion of dynamical similarity, is very interesting. The author's object in presenting his paper was to call attention to the method which, he is convinced, will in time come to be one of the engineer's handy tools, like the two laws of thermodynamics. But since he is aware that his opinion of the value of the method may be received somewhat sceptically by professional engineers, tes-

timony in its favor from one engaged in practical designing work is doubly welcome.

In reply to Mr. Hersey, mechanical engineering is an art, not a science; and the ability and imagination of the individual engineer will always be its most important element. But common sense tells the engineer to get as much outside help as he can in solving his problems, and one source of such help is physics. As Mr. Hersey points out, the aid to be got from physics does not consist merely in new determinations of physical constants or in experimental investigations of physical problems which are of special interest to engineers. It consists also in the systematic use of the scientific method of physics in analyzing problems, planning experiments, and coördinating known facts so as to bring to bear on any new problem all the available knowledge, of whatever sort and wherever obtained, which may seem to be pertinent. This is the technical physics which is destined not only to work in its laboratories on problems presented by engineers, but to be recognized as an inseparable companion of sound and progressive mechanical engineering.

# ON THE LAWS OF LUBRICATION OF JOURNAL BEARINGS

BY M. D. HERSEY, WASHINGTON, D. C.

Member of the Society

In order to establish a rational basis for bearing design, it would be desirable to have empirical equations, or curves, showing accurately and completely how the friction loss and load-carrying power of bearings depend on all the physical conditions governing the action of lubrication, including, of course, the size, shape, and fit of the bearing, the speed, degree of lubrication, properties of the lubricant, and characteristics of the cooling system. The problem of mapping out the laws of lubrication in this general way, whether by piecing together existing data or by making new experiments, is such a complicated one that it is worth while to stop and consider whether any general principles are available which may serve to simplify it. A recognition of the above facts has led to the present paper.

*Relation of laws of lubrication to design.* After the requirements of strength and rigidity have been met, there may remain a question as to length and diameter which must be settled by reference to the laws of lubrication. Evidently too short a bearing is in danger of abrasion, while too long a bearing entails needless dissipation of power.

Let the coefficient of friction, $f$, be defined by the equation

$$f=\frac{F}{L} \qquad [1]$$

in which $F$ is the frictional resisting force and $L$ the load on the bearing perpendicular to its axis. Let the bearing pressure, $p$, be defined by the equation

$$p=\frac{L}{l\,D} \qquad [2]$$

in which $l$ is the length of the bearing and $D$ the diameter of the journal. Let $p_o$ denote the carrying power or greatest permissible bearing pressure. Then the shortest permissible length of a bearing, $l_o$, may be calculated from the equation

$$l_o=\frac{L}{D}\cdot\frac{1}{p_o} \qquad [3]$$

while the power dissipated in this bearing at a speed of $n$ revolutions per unit time will be

$$P=\pi\,D\,n.L\,f \qquad [4]$$

Equations [3] and [4] are purely formal and their practical use demands a knowledge of some relation

$$f=\phi\,(p, n, D, l, \text{etc.}) \qquad [5]$$

between the coefficient of friction and all the physical quantities governing the action of lubrication; together with some relation

$$p_o=\psi\,(n, D, l, \text{etc.}) \qquad [6]$$

between carrying power and the factors which it may depend upon.

Equations [5] and [6] symbolize the most important of the laws of lubrication needed in design; and they may be termed the *law of friction* and the *law of carrying power* respectively.

*Definitions of friction and carrying power.* Already the coefficient of friction has been defined as the ratio of frictional resistance to the load on the journal perpendicular to its axis; while carrying power has been defined as the greatest permissible bearing pressure.

A satisfactory definition of permissible bearing pressure demands a definite understanding as to the type of failure we wish to avoid. If we wish to avoid failure by seizing, we must investigate thermal expansion; if we wish to avoid failure by overheating the lubricant, we must investigate the temperature rise; if to avoid creating tension in the lubricant, we must investigate the pressure distribution; if to avoid simple abrasion, we must investigate the minimum film thickness. The last type of failure is the only type we shall undertake to discuss in this paper.

If $c$ denotes the *radial clearance* or mean difference in radii between journal and bearing, while $x$ denotes the *film thickness* or thickness of the film of lubricant at the point of nearest approach, the fraction $\frac{x}{c}$ may be called the *relative film thickness*. In this paper, we shall make it a matter of definition that all bearings are equally *safe* which are running with the same relative film thickness. Accordingly, carrying power may be defined as that bearing pressure which reduces the relative film thickness to some prescribed value $\left(\frac{x}{c}\right)$.

The determination of the laws of lubrication symbolized by equations [5] and [6] therefore simmers down to the investigation of the effect of various conditions on $F$ and $x$.

*Restrictions necessary to exclude unfamiliar phenomena.* In order to narrow the problem down to as simple a one as possible we may impose the following restrictions:

1 The bearing must be in a steady state.
2 The lubricant must be homogeneous.
3 The bearing must be running below the critical speed at which eddy motion would be set up in the lubricant.
4 The effect, on the motion of the lubricant, of any other forces than hydrostatic pressure and shearing stress must be negligible.
5 The metal surfaces must always be separated by a film of lubricant which is thick enough to have the same mechanical properties it would have in bulk.

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6 There must be no resultant couple acting on the bearing in the plane of its axis.

*Qualitative discussion of action of lubrication.* It is now shown qualitatively that, under the foregoing restrictions, $F$ and $x$ are completely determined by the following physical quantities:

*a* The viscosity, $\mu$, of the lubricant.

*b* The revolutions per unit time, $n$.

*c* The load, $L$.

*d* The degree of lubrication; which, in the case of *stationary* lubrication (i.e., the limiting case when no lubricant enters or leaves the bearing) may be specified by $V$, the volume of lubricant in the bearing; and which in the case of forced lubrication may be specified by the quantity, $Q$, of the lubricant flowing through the bearing in unit time. Let $S$ denote the relative supply $\frac{V}{Dlc}$.

*e* The absolute size of the bearing, which may be given by the diameter of the journal, $D$.

*f* The line of action of the load, defined by some length ratio $r'$ such as the ratio or its distance from the middle point of the bearing, to the diameter.

*g* The shape of the bearing; specified by the relative clearance $\frac{c}{D}$, the relative length $\frac{l}{D}$ and such other length ratios $r''$, $r'''$, etc., as may be needed to fix the shape of the oiling arrangements, deviation from circular section due to wear, departure from cylindrical form due to strain, and all other geometrical irregularities. Let $r$ denote all the ratios $r'$, $r''$, $r'''$, etc.

The conclusion that $F$ and $x$ depend only on $\mu$, $n$, $L$, $V$, $Q$, $D$, $\frac{c}{D}$, $\frac{l}{D}$, $r$, may be symbolized by the equations

$$\Phi\left(\frac{F}{L}, \mu, n, L, V, Q, D, \frac{c}{D}, \frac{l}{D}, r\right)=0 \quad [11]$$

and

$$\Psi\left(\frac{x}{D}, \mu, n, L, V, Q, D, \frac{c}{D}, \frac{l}{D}, r\right)=0 \quad [12]$$

*Derivation of the general form of the laws of lubrication by dimensional reasoning.* An application of Buckingham's Π-theorem to equations [11] and [12] throws them respectively into the forms

$$f=\phi\left(\frac{\mu n}{p}, \frac{D^3 n}{Q}, S, \frac{c}{D}, \frac{l}{D}, r\right) \quad [20]$$

and

$$p_0=\mu n . \theta\left[\left(\frac{x}{c}\right)_0, \frac{D^3 n}{Q}, \frac{c}{D}, \frac{l}{D}, r\right] \quad [21]$$

$f$ and $p$ making their appearance in place of $F$ and $L$ by virtue of equations [1] and [2]. The functions $\phi$ and $\theta$ are of course unknown, and remain to be determined by experiment.

Equations [20] and [21] correspond to equations [5] and [6] respectively, and contain the two laws of lubrication in their most general form. Now, any two bearings in which $\frac{D^3 n}{Q}$ has the same value, and in which $S$ also has the same value, may be called *similarly lubricated.* Hence [20] and [21] are equivalent respectively to the following statements:

*a* In geometrically similar bearings which are similarly loaded and lubricated, the *coefficient of friction depends only on the single variable* $\frac{\mu n}{p}$

*b* *The carrying power of any bearing is directly proportional to the product of viscosity by revolutions per unit time,* the constant of proportionality being the same for all geometrically similar bearings which are similarly loaded and lubricated and which are equally safe, i.e., $\left(\frac{x}{c}\right)_0$ constant.

The writer made a series of experiments on journal friction and carrying power several years ago, the results of which are entirely consistent with the above conclusions.[1]

*Dynamically similar bearings.* Any two geometrically similar bearings $B$ and $B'$ which are similarly loaded and lubricated, and which are running at the *corresponding* speeds, pressures, and viscosities defined by the equation

$$\frac{\mu n}{p}=\frac{\mu' n'}{p'} \quad [30]$$

have the same coefficient of friction and the same relative film thickness. Such bearings may be termed *dynamically similar.* The power dissipated in either of them may be calculated from a test made on the other, for

$$\frac{P}{P'}=\frac{D}{D'} \cdot \frac{n}{n'} \cdot \frac{L}{L'} \quad [31]$$

Moreover,

$$\frac{p_0}{p'_0}=\frac{\mu}{\mu'} \cdot \frac{n}{n'} \quad [33]$$

Thus if the carrying power of one bearing has been found experimentally, that of the other can be at once calculated.

*A general method for determining thermal effects.* The principal effect of temperature, and the only effect we need analyze here, is to decrease the viscosity of the lubricant as the bearing heats up. Consequently both friction and carrying power increase with speed less rapidly, under working conditions, than they would at constant temperature. The general dynamical equations [20] and [21] are true regardless of temperature, because they have been expressed in terms of the actual viscosity of the lubricant in the film at the moment in question; but it is desirable to go a step further. Equations like [20] and [21], which describe the behavior of a bearing when the viscosity is given, may be termed *characteristic equations* for that bearing. On the other hand, an equation describing the behavior of a bearing, not in terms of the instantaneous viscosity, but entirely in terms of known constants or controllable conditions like speed and load, may be termed a *working equation* for that bearing. Such an equation does not characterize the bearing in itself, but depends also on the nature of the lubricant and on the cooling system. A general method for determining the working equations for the friction and carrying power of any bearing is now outlined. The method consists in eliminating viscosity from the characteristic equations by utilizing information about the lubricant and the cooling system. Five relations are available, namely those connecting the quantities

$p_0$ and $\mu$
$\mu$ and $t$
$t$ and $H$
$H$ and $f$
$f$ and $\mu$

respectively.

The first of these is the characteristic equation for carrying power, equation [21].

Any empirical equation for the viscosity of an oil in terms

[1] For a brief account of the experiments, see Jour. Wash. Acad. Sci., v. IV p. 549, 1914.

of temperature must involve certain constants, which are different for different oils; if we denote all these by $a$, the second relation can be written

$$\mu = F_1\ (t,\ a) \qquad [34]$$

in which the function $F_1$ is supposed to have been determined empirically.

Likewise the heat carried away in unit time at any temperature $t$ may be expressed by some empirical equation

$$H = F_2\ (t,\ b) \qquad [35]$$

in which $b$ denotes all of the constants entering the function $F_2$.

The fourth relation is obtained by equating $J$, the mechanical equivalent of the heat carried off in unit time, to the power dissipated according to equation [4].

The fifth relation is the characeristic equation [20] for the coefficient of friction.

Eliminating $\mu$ and $H$ from the five relations leads to the three general equations

$$p_o = F_1\ (t,\ a)\ .\ n\ .\ \theta \left[ \left( \frac{x}{c} \right)_o, \frac{D^3\ n}{Q}, R \right] \qquad [37]$$

$$F_2\ (t,\ b) = \frac{\pi}{J}\ D^2\ l\ n\ p\ .\ \phi \left[ \frac{F_1(t,\ a)\ .\ n}{p}, \frac{D^3\ n}{Q}, R \right] \qquad [38]$$

$$f = \phi \left[ \frac{F_1\ (t,\ a)\ .\ n}{p}, \frac{D^3\ n}{Q}, R \right] \qquad [39]$$

in which $R$ has been written for all the ratios $S, \frac{c}{D}, \frac{l}{D}$, and $r$. These three relations may be regarded as a formal statement of the proposed method for determining thermal effects. The functions $\theta$ and $\phi$ are to be found by dynamical experiments; $F_1$ and $F_2$ by thermal experiments. After they have been determined, we can deduce a working equation for the carrying power by eliminating $t$ from [37] and [38]. Likewise, by eliminating $t$ from [38] and [39], we can deduce a working equation for the coefficient of friction. From [38] alone we get an equation for the permanent running temperature of the bearing.

If any of the empirical functions $\theta$, $\phi$, $F_1$, or $F_2$ prove too complex to represent analytically, we can still accomplish the desired eliminations graphically.

The relations [37], [38], and [39] are perfectly general and not limited to any particular type of bearing or to any particular lubricant or cooling system.

*Properties of the Ideal Bearing.* The paper closes with a discussion of the *ideal bearing*—one which is perfectly circular in cross section, completely filled with lubricant, etc. While intended primarily as an illustration of the foregoing relations, and not for actual use in design, the equations of the ideal bearing doubtless afford an approximation to the laws of actual bearings. The characteristic equations for the coefficient of friction and carrying power of a *high speed* bearing, or ideal bearing with approximately concentric journal, are respectively

$$f = \phi \left( \frac{\mu\ n}{p}, \frac{c}{D} \right) = \pi^2 \frac{D}{c} \frac{\mu\ n}{p} \qquad [43]$$

and

$$p_o = \theta \left[ \left( \frac{x}{c} \right)_o, \frac{c}{D} \right] .\ \mu\ n = A\ \ \mu\ n \qquad [44]$$

in which the constant $A$ is supposed to have been determined empirically.

The following are convenient approximations for the viscosity and cooling functions respectively:

$$\mu = F_1\ (t,\ a) = \frac{\mu_o\ (t_o - \tau)}{t - \tau} \qquad [47]$$

and

$$H = F_2\ (t,\ b) = h\ (t - t_o) \qquad [48]$$

Here $\mu_o$ is the viscosity at the room temperature $t_o$; $\tau$ is the fictitious solidifying temperature; $h$ the heat carried off in unit time per unit temperature elevation above room temperature.

If in [37], [38], [39], we now substitute the expressions for $\phi$, $\theta$, $F_1$, $F_2$, given respectively by [43], [44], [47] and [48], the following working equations result:

(a) For the permanent running temperature:

$$t = \tfrac{1}{2}\ (t_o + \tau) + \tfrac{1}{2}\ (t_o - \tau)\ \sqrt{1 + k\ n^2} \qquad [59]$$

in which

$$k = \frac{4\ \tau^3}{J} \cdot \frac{\tau_o}{h\ (t_o - \tau)}\ .\ D^3\ .\ \frac{\left(\frac{l}{D}\right)}{\left(\frac{c}{D}\right)} \qquad [60]$$

The quantity $k$ may be termed the *heating constant;* the greater it is, the hotter the bearing will run at any given speed. Evidently $k$ may be determined from an observation of the permanent running temperature at any one speed, for by solving [59] for $k$ we see that

$$k = \frac{\left( \frac{2\ t - t_o - \tau}{t_o - \tau} \right)^2 - 1}{n^2} \qquad [61]$$

(b) For the coefficient of friction:

$$f = \pi^2 \frac{D}{c} \frac{\mu_o\ n}{p} \left[ \frac{2}{1 + \sqrt{1 + k\ n^2}} \right] \qquad [62]$$

(c) For the carrying power:

$$p_o = A\ \ \mu_o\ n \left[ \frac{2}{1 + \sqrt{1 + k\ n^2}} \right] \qquad [63]$$

The above results apply only to the high speed bearing, for it is only when the journal is concentric that [43] is valid. The complete paper, however, contains a corresponding treatment of the ideal bearing with eccentric journal. Sommerfeld's work is made use of in this connection, and extended by an analysis of heating effects.

The paper contains illustrative examples, worked out numerically, and accompanied by diagrams.

*Conclusion.* It is apparent that the next step should be a minute examination of existing data, in the light of the foregoing principles. If it then appears that further experiments are needed, we may be guided as to the most economical way to plan them by reference to the general dynamical relations [20] and [21], and to the general thermal relations [37], [38], [39]. The dynamical relations serve to diminish the number of independent variables entering the characteristic equations. (Thus, the effect of varying all the factors $\mu$, $p$, $n$, $D$, $Q$, can now be attained by changing two alone, such as $\mu$ and $Q$.) The thermal relations serve to diminish the number of combinations of conditions needed in determining working equations. It is a confusing task to map out the working equations of bearings under any great variety of circumstances by direct experiment, but a relatively simple matter to determine the dynamical characteristics of a bearing ($\phi$ and $\theta$), and the thermal properties of a lubricant ($F_1$), and of a cooling system ($F_2$), by sepa-

rate sets of experiments. (Thus, in certain cases the function $F_2$ might be determined with a stationary dummy bearing, in which the heat is generated, regulated, and accurately measured electrically). It appears from this paper that it will be permissible to conduct such experiments separately; after which the results can readily enough be combined by the general thermal relations [37], [38], [39].

Finally, the conception of dynamically similar bearings may make it possible to evaluate some of the constants needed in design by the use of models—meaning of course by the model, any bearing whatever, found satisfactory in actual service, and which meets the condition of being dynamically similar to the bearing about to be designed.

## DISCUSSION

H. F. Moore. The paper appeals to the writer as an excellent example of the use of mathematical reasoning to facilitate and interpret experimental work. Coöperation between the mathematicians and experimenters is one of the most desirable technical achievements; many a carefully made set of experiments has gone for naught because of lack of analytical interpretation of results, or of proper theoretical lay-out of the tests, and many careful mathematical analyses have been valueless because the fundamental constants were wrongly assumed or not determined with sufficient accuracy.

The author's results on carrying power are qualitatively confirmed by the writer's experience. Experiments made by him in 1903 with a bearing of babbitt metal on a steel journal showed that the carrying power of the bearing before the film of oil broke down increased with some function of the speed, and so far as the tests went the bearing power was found to vary approximately with the square root of the speed. Later tests made at the University of Wisconsin on very carefully ground hardened steel journals rotating in bronze bearings showed a carrying power two or three times as great as did the babbitt metal bearing with unhardened journal. It might be expected that surface finish of journal and bearing would play a very important part in determining the breaking strength of the oil film.

W. H. Herschel. The author's work is a notable step in bringing order out of the chaos of experiments on the friction of journals. If it can be demonstrated that viscosity is the only property of the lubricant which influences the coefficient of friction and the maximum permissible load, lubricating problems will be greatly simplified. Thanks to Sommerfeld, we no longer feel the necessity of considering "adhesion" which was introduced into equations by the earlier investigators, but there is a widespread belief that lubricants vary in regard to "oiliness," "lubricating value" or "body."

F. zur Nedden contributed a written discussion in which after comparing the author's results with recent experiments carried out by Professor Guembel in Germany and described in the Monatsblätter des Berliner Bezirks-Vereines Deutscher Ingenieure, May and June, 1914, he continued:

When gradually reducing (at constant pressure $p$) the speed of any bearing the value of the coefficient of friction in the neighborhood of zero, after reaching a minimum, abruptly increases to a high figure, because with very low speeds the liquid friction is giving way to semi-dry friction. The laws as set forth in the paper do not then hold good. The point where this change occurs depends among others on the smoothness of the gliding surfaces. This consideration is by no means only of theoretical interest. Toothed wheels when running in oil will show lesser friction losses if designed so that the flanks of the teeth glide on each other with a speed exceeding the upper limit of semi-dry friction.

The all-important question whether equations (11) and (12) are qualitatively complete should be further investigated in connection with a long series of very important tests which Professor Schlesinger has brought forth in contention of the idea that it is not correct to assume that the only factor that matters in a lubricant (besides its price) is its viscosity.

The writer has come to the conclusion that two properties of the lubricant probably have something to do with the process of lubrication, both of which are not covered by the author's formulæ. The first and less important one is the heat capacity of the oil itself, i.e., its specific heat. The second and very important one is the degree of amorphity. Lubrication depends entirely on the wedgelike action of the lubricant film. If the resistance of the lubricant against the mutual dislocation of its molecules is not absolutely the same regardless of the direction of the outer forces which tend to dislocate them, in other words, if the lubricant can no longer be regarded as a real amorphous liquid, then the application of Newton's law of viscosity will have to be modified.

Apart from optical reasons the change in the lubricating qualities of oils after some period of running would indicate that molecular forces are at work within lubricants which affect their action while not appreciably affecting their viscosity as measured by one of the ordinary viscometers.

Several very important conclusions can be drawn by the practical engineer from the results in this paper. One of the stipulations which is to be found in almost every specification for turbo-machinery is that the length of the bearings should at least equal three times the diameter. This rule of thumb probably is the outcome of practical experience gained with bearings of the comparatively low speed machinery exclusively used before the advent of the steam turbine. From the paper it follows the carrying power is different at different speeds.

The viscosity of the oil and the heat carrying capacity of the bearing are the essential standards which should be determined, but which are scarcely ever mentioned in any specification.

Of these two factors one depends on the buyer who supplies the lubricant for the machine he buys. Only the second factor, the heat carrying capacity, depends on the make. It is highly gratifying that the author shows a way to determine this quality of a bearing in a manner which will permit of standardization.

Until definite standards are developed, it would appear the safest way for a buyer to ask the maker for a guarantee of the temperature of the bearing, or rather of the maximum difference between room temperature and bearing temperature, provided such and such an oil is used.

In conclusion the writer considers the engineers of this country owe a very great debt of gratitude to the author for this valuable paper, and expresses the hope that his endeavors to map out the proper and most direct course for

the establishment of a rational basis for bearing design will be rewarded by a corresponding organization of the necessary experiments. If all individuals and laboratories, especially those of the Universities, who at present contemplate experimenting on the problem of lubrication of bearings could come together and assign among each other in a systematic and efficient manner the treatment of the various subproblems as indicated by the present paper—then progress in the knowledge of bearing construction should be quick and radical.

THE AUTHOR. In discussing the value of coöperating with mathematicians, Professor Moore evidently refers to mathematics in the customary sense in which the term is stretched to include physics as well, but the writer would urge that we break this custom, and always distinguish physical reasoning from mathematical reasoning. The distinction may seem hair-splitting at times, and yet we all know what havoc has been wrought in the field of elasticity, for example, by elaborating mathematically relations physically unwarranted. Aside from the Π-theorem, which owes its value solely to its capacity for summing up physical facts, there is no mathematics at all in the important part of my paper, namely, the first twenty-five pages. What looks to be mathematics is merely symbolism—shorthand. The conclusion that a bearing can support a heavier load the faster it runs, follows from the physical facts about viscosity; and the general method for grinding out working equations is merely a condensed statement of a group of facts about heating and cooling, familiar enough to physicists, but which the cleverest mathematician alive might not have heard of.

Professor Moore's own formula, the square root law of carrying power, has been unwarrantably extended by others, and applied to circumstances physically different from those under which it was established. Nevertheless, the historical significance of his experiments of 1903 can hardly be overestimated. They were the first experiments aiming toward a direct determination of carrying power.

While experimenting with bearings in 1909 at the Massachusetts Institute of Technology it occurred to the writer to see whether this square root law or any similar relation held under more nearly practical conditions; that is, with a whole bearing instead of a half bearing, and at higher speeds. It turned out that under these circumstances complete film rupture never took place, but that the load producing some specified electrical resistance other than zero did increase with speeed.

As noted by Professor Moore it is to be expected that (except at high speeds), bearings with differently finished surfaces will behave differently; they cannot be considered geometrically similar unless they are either sensibly smooth or similarly rough—not equally rough, but twice as rough if twice as big.

Mr. Herschel alludes to the widespread belief that oils of the same viscosity may still differ in lubricating value. This belief is doubtless correct as regards bearings running at low enough values of $\frac{\mu n}{p}$.

It would not be proper to comment in detail on Professor Guembel's work until Mr. zur Nedden's own discussion is printed in full. One fact may, however, be recorded for the interest of those who consult that reference in the meantime: If the curves on which Professor Guembel's final equations are based be fitted at three points instead of two, a more general type of equation results, which reduces to Guembel's at low values of $\frac{\mu n}{p}$ and to Sommerfeld's at high.

It is true that the present paper is inadequate to cope with semi-dry friction, and it is likely that Professor Schlesinger's experiments, dealing as they do with the aggregate friction losses of the engine lathe, are largely concerned with semi-dry friction.

The specific heat of the oil has to be regarded as one of the $b$'s of equation [35] for heat carried off.

The writer does not believe there is, as yet, any need for considering the effect of incomplete amorphity.

Mr. zur Nedden's suggestions are exceedingly interesting, and must certainly be taken account of in the subsequent development of the subject. But, for the moment, we are so much at sea that it is well to follow the rule of navigation and keep to deep water, in doing which our six fundamental restrictions will serve as the channel buoys. Any exact charting out of the shoals has, to be sure, been postponed.

# INFLUENCE OF DISK FRICTION ON TURBINE PUMP DESIGN

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Member of the Society

## INTRODUCTION

A DISK revolving in water acts as a brake. The losses due to the rotation of impellers in the water surrounding them amount t oone-quarter to one-third of the total of the losses occurring in a high-lift turbine pump. It is astonishing that publications on the nature and magnitude of these losses are more scarce.[1, 2, 3, 4] There is very little reliable information on the question and that little is not araruged as designers would like to hav it for us in commercial practice.

In the present paper, the results gained by Prof. A. H. Gibson[4] are mainly employed in an effort:

*a* To find what means are at the disposal of the designer of turbine pumps for minimizing the losses due to disk friction.

*b* To furnish reliable data and diagrams from which to estimate the influence of disk friction on the efficiency of a turbine pump.

*c* To draw attention to the bearing which disk friction of the impellers has on the axial thrust of turbine pumps.

## NOTATION

$\kappa_A$ and $\kappa_B$ = coefficients of friction between surfaces $A$ and $B$ respectively on one hand and the fluid surrounding the disk on the other hand.

Waste-water = fluid surrounding the disk.

$f$ = Gibson's coefficient of disk friction.

$v_T$ = abs. velocity of waste-water in ft-sec. at the distance $r$ from the axis.

[1] "Experiments on the Friction of Disks Rotated in Fluid." Minutes Proc. Inst. Civ. Eng., London, vol. lxxx, p. 221 ff.
[2] Bulletin No. 2, Univ. of Cal., Berkeley, Cal., 1887.
[3] Wirkungsweise der Kreiselpumpen; Mitteilungen ueber Forschungsarbeiten, Verein Deutscher Ingenieure, Heft 42, Berlin, 1907.
[4] Min. Proc. Inst. Civil Eng., London, vol. clxxix, 1910, part i.

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$v_\rho$ = absolute velocity in ft-sec. of a point situated on the surface of the disk at a distance of $\rho$ from the axis.

$v_{\rho A}$ = abs. velocity in ft-sec. of adjacent particle of waste-water.

$v_{\rho B}$ = abs. velocity in ft-sec. of waste-water particles adjacent to casing at distance $\rho$ from axis.

$O_A$ = area in sq. ft. of that part of the impeller surface which is marked by fat contour in upper half of Fig. 1.

$O_B$ = area in sq. ft. of surface of casing as marked by fat contour in upper half of Fig. 1.

$P$ = dragging force in pounds of impeller, i.e., force exerted by impeller on waste-water which it causes to rotate.

$Q$ = retarding force, in pounds, of casing, resisting effects of $P$.

$\omega_T$ = angular velocity per sec. of waste-water.

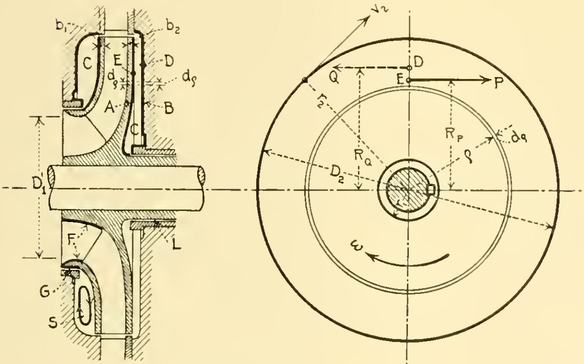


Fig. 1 Key to Notation

$\omega$ = angular velocity per sec. of impeller.

$J_A$ = polar moment of inertia in ft⁴, of surface $O_A$ with respect to axis of rotation.

$J_B$ = the same of surface $O_B$

$R_p$ and $R_q$ = distance, in feet, of $P$'s or $Q$'s place of application respectively from axis of rotation.

$E_r$ = energy of disk friction in ft-lb.

$h_g$ = gyrostatic head in ft.

$h_s$ = static head generated by impeller proper in ft.

$D_1$ = diameter of slip ring clearance in ft.

$D_2$ and $R_2$ = diameter and radius respectively of impeller in ft.

$P_g$ = total gyrostatic force in lb., see equation [9].

$P_s$ = total axial force exerted by gyrostatic plus static pressure on the impeller in lb., see equation [10].

$N_T$ = number of revolutions of waste-water per min.

$N$ = number of revolutions of pump per min.

After pointing out the conditions when and where the disk friction may be expected to be the smallest possible, the author makes the following deductions:

*a* In order to reduce the loss through disk firction as much as possible, the coefficients of friction $\kappa_A$ and $\kappa_B$ should be made as small as possible; i.e., both the casing and the runner should be machined or polished as smoothly as possible.

*b* If a smoothly finished impeller revolves within a rough casing of a lateral width not exceeding about 5 per cent of the diameter of the impeller, the result is the same as if a rough impeller revolves within a smooth casing.

*c* The surface of the impeller and of the stationary parts of chamber *C* (Fig. 1) should be made as small as possible.

*d* The effect of an extended and complicated surface is equally bad whether this surface be the stationary wall of chamber *C* or the rotating surface of the impeller.

*The outward indication of the attainment of a minimum of loss through disk friction is the fact that the waste-water rotates just half as quickly as the impeller.*

THE GYROSTATIC PRESSURE

*The pressure due to the rotation of the waste-water is the source of important axial forces.* At a distance of $r$ ft. from the axis of rotation and an angular velocity of $\omega_T$ per sec. this pressure in feet of fluid is

$$h_g = \frac{\omega_T^2 r^2}{2g} = \frac{v_T^2}{2g}$$

where $v_T$ stands for the absolute tangential velocity of the waste-water in ft-sec. and $g$ = 32.16 ft-sec.

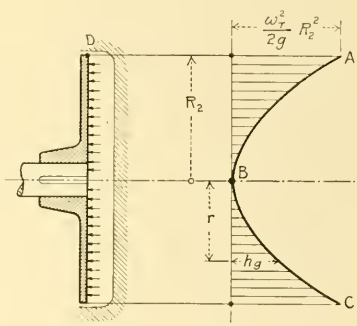


Fig. 2 Gyrostatic Parabola

When plotting these pressures as abscissæ over the respective radii as ordinates, the parabola *A B C*, Fig. 2, is obtained. The pressure $h_g$ is directed towards the circumference.

In turbine pumps the problem is to find the influence of the gyrostatic pressure upon annular surfaces, say, e.g., that part of the impeller which lies between slip ring *a* and its periphery (Fig. 3).

*The gyrostatic force in pounds axially exerted by the rotating waste-water upon an annular surface is shown in this section to be*

$$P_g = \frac{N_T^2 (D_2^4 - D_1^4)}{1000} \quad \ldots\ldots\ldots\ldots [9]$$

where

$N_T$ = rotative speed of waste-water in r.p.m.

$D_2$ and $D_1$ = the outer and the inner diameter, respectively, of the surface in ft.

and the total axial force in a pump which generates static pressure.

$$P_s = 49(D_2^2 - D_1^2)\left(h_s - \frac{4.25 N_T^2 D_2^2}{100{,}000}\right) + P_g \quad \ldots\ldots\ldots [10]$$

where

$D_2$ and $D_1$ = outer and inner diameter, respectively, of annular face, in ft.

$h_s$ = static head existing at circumference of impeller, in ft.

$N_T$ = rotative speed of waste-water in r.p.m.

$P_g$ = gyrostatic force (see equation [9]).

The paper here surveys the experiments of Unwin and Gibson, considering the limitations of their formulae and also that of Biel for the theoretical loss through disk friction. It then develops the following expression:

$$h.p.f^1 = \frac{4\pi^{n+2}f}{550.30^{n+1}.2^{n+3}}\, N^{n+1}\, \frac{D_2^{n+3}}{n+3} \quad \ldots\ldots [12]$$

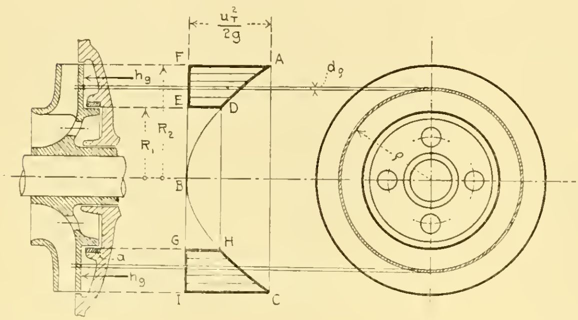


Fig. 3 Gyrostatic Force Acting upon Annular Surface

where

$h.p.f$ = loss due to friction on both faces of disk, without considering axial thickness, in h.p.

$f$ = coefficient of friction, see Fig. 5, $a$, $b$ and $c$.

$n$ = exponent of friction, see Fig. 5, $a$, $b$ and $c$.

$N$ = r.p.m. of disk.

$D^2$ = largest diameter of disk.

This formula does not take into account the axial extension of the disk and so the author develops a corrective factor for use of designers, viz.:

$$h.p.f_b = h.p.f^1 \times \left[\frac{b}{D_2}.(n+3)\right] \ldots\ldots\ldots\ldots\ldots [14]$$

That is, in order to find the total loss due to *friction both of the circumferential and the lateral faces* of a disk, the value of $h.p.f^1$ obtained for the latter (equation [12]) should be multiplied by

$$1 + \frac{b}{D_2}(n+3) \ldots\ldots\ldots\ldots\ldots\ldots [15]$$

where $b$ is the total axial thickness of the disk, expressed in the same measure as $D_2$.

In this way the designer can always, by a simple factor to be worked out mentally, consider separately and keep apart the influence of the diameter and that of the axial extent of an impeller on the friction loss.

### Influence of Roughness of Disk and Casing

Figs. 5 $a$, $b$ and $c$ represent graphically the average variations of $f$ and $n$ in function of $v_2$ as established by Gibson and Ryan for various degrees of roughness. Their results were compiled with those established by Professor Unwin's experiments and found to harmonize with them to a satisfactory degree. As set forth in Figs. 5 $a$, $b$ and $c$ the values of $f$ and $n$ furnish, within the range of speeds at which turbine pumps are run, figures for the losses (equations [12] and [14]) which always come within 5 per cent of the actual test results.

The second deduction at which the author arrived by a mathematical survey in this paper, viz.: "If a smoothly finished impeller revolves within a rough casing, the result

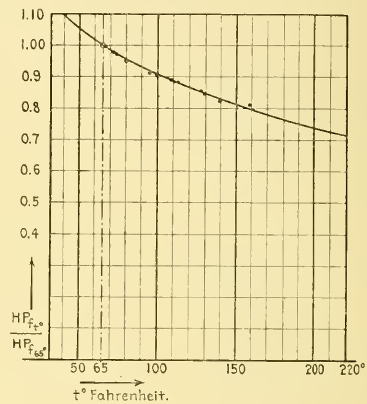


Fig. 4 Disk-Friction Loss as Function of Temperature of Waste-Water

is the same as if a rough impeller revolves within a smooth casing," is well corroborated by these curves.

The effect of metal polish and of varnish is amost exactly the same. This result should, however, not encourage manufacturers to restort to varnishing rather than machining the surfaces. Varnishing or japanning appears only at first sight to be the cheaper process. As a matter of fact, two coats of varnish require rather a long time to dry thoroughly. If the varnish or lacquer is not applied very carefully and dried well, or if the fluid to be pumped is not absolutely clean, the varnish will peel off. The surface then acts worse than even a rough casting. Polished surfaces, on the other hand, will often lose much of their original finish by the sediments of the water in the pump. It is, therefore, of no great use to expend much time and wages on a high, shining exterior finish of the impellers. It is sufficient to turn the faces off with a medium heavy cut, especially as the turning ruts are running concentric, i.e., in the direction of the flow of the waste-w ter.

Much saving can be effected if designers and shops coöperate in producing the smoothest possible castings to surround the waste-water chamber. This chamber should offer a minimum of surface and be free of any ribs, protrusions or re-

cesses which not only increase the surface and impede the rotation of the waste-water, but also frequently give rise to rough castings. If the designer gives the walls of the chamber a shape of utmost simplicity, the foundry will be able to produce faultless, smooth castings without extra cost.

Considerable though the differences due to various degrees of ordinary roughness in new pumps may at first seem, still it is only with typical high lift pumps that they appreciably affect the efficiency of the pump. This is especially true where the duty is small in comparison with the head per stage.

The paper here gives an example to illustrate this thesis.

### INFLUENCE OF VISCOSITY, TEMPERATURE AND SPECIFIC GRAVITY OF FLUID ON DISK FRICTION

Inasmuch as oil, gasoline, hot water, etc., are today pumped by turbine pumps, the consideration of these influences gains in importance. The author has found it possible to answer the question of their respective magnitudes by a simple application of the theory of dimensions.

By considering the dimensions upon which the magnitude of the resistance depends, the expression

$$h.p.f^1 = k^1 \sqrt[5]{\frac{\mu . w^4}{s}}\; v^{2.8} d^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots [23]$$

where $\mu$ = absolute coefficient of viscosity.

$w$ = specific gravity.

$s$ = lateral width of casing.

is deduced. It is easily seen that this is substantially identical with formula [12].

Fig. 4 represents the variation of $h.p.f$ with the temperature of the water. This curve may be utilized for estimating the improvement in power consumption which may be expected when a pump which has been tested with cold water (65 deg. fahr.) is eventually used, say, as a boiler feed pump and deals with water 200 deg. fahr.

Of course, in a pump all the other causes inherent to the change of temperature are at work at the same time. For instance the loss of head owing to hydraulic friction in the fixed and rotative channels of the pump is likewise diminishing. On the other hand, the leakage loss must increase as the fluid becomes less viscous. The balance of all influences tends slightly to improve the efficiency of a boiler feed pump in actual service as compared with the figures obtained when testing it with cold water. The paper gives two examples illustrating the influence of heavy oil and tarry liquid on the disk friction in a turbine pump.

### INFLUENCE OF DIAMETER AND SPEED

Formula [12] with $n = 1.8$ to 2, reveals at once the tremendous role the diameter plays. The influence of the rotary speed $N$ is of relatively minor importance, though it is in proportion to about the third power of the number of revolutions.

As the duty of a turbine pump is in proportion to the speed, and the head in proportion to its square, the useful output is increased in proportion to the third power of the speed. It will be seen, therefore, that the *loss through disk friction must form a constant percentage of the normal useful output, (water-h.p.), of a given pump irrespective of speed.*

*High heads per stage are more economically produced by applying high speed than by using a large diameter of the impeller.* This economic tendency for the high-speed pump is fostered by a number of other incidental advantages, e.g., alternating current electric drive, direct steam turbine drive, small unit costs, small weight, reduction in tensile stress on casing, compactness, ease in transport and repairs, etc.

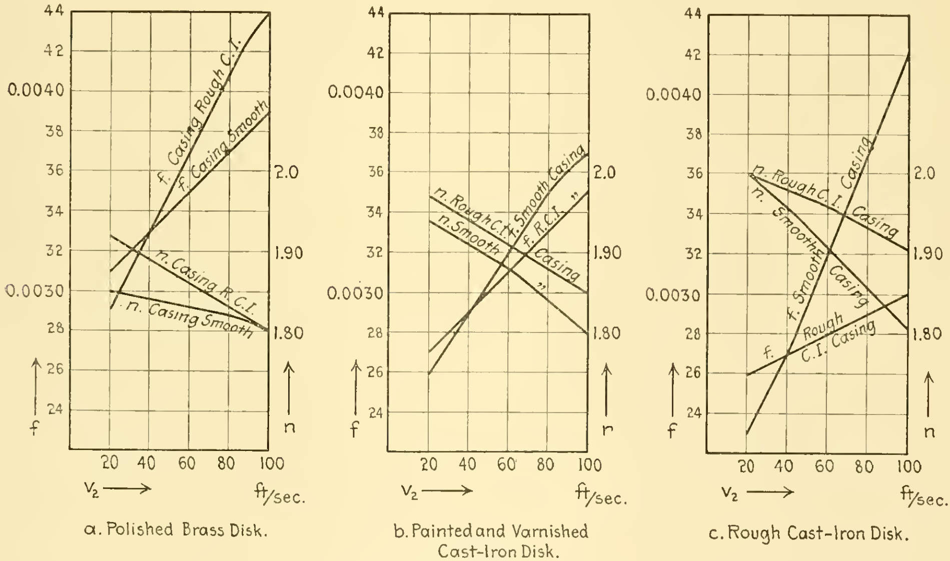


FIG. 5 DIAGRAMS OF DISK FRICTION ON POLISHED, PAINTED AND ROUGH SURFACES

It might not be out of place to point out that *the angle between the impeller blades and the tangent at the periphery* has an important bearing on the loss through disk friction. If this angle is made 20 deg. the diameter must, from hydraulic reasons, be larger by 10 to 25 per cent, than if the angle were 45 deg. This implies for the flatter angle an increase in disk friction of at least 60 to more than 150 per cent in some cases. As the disk friction loss expressed in percentage of the useful work amounts seldom to less than 5

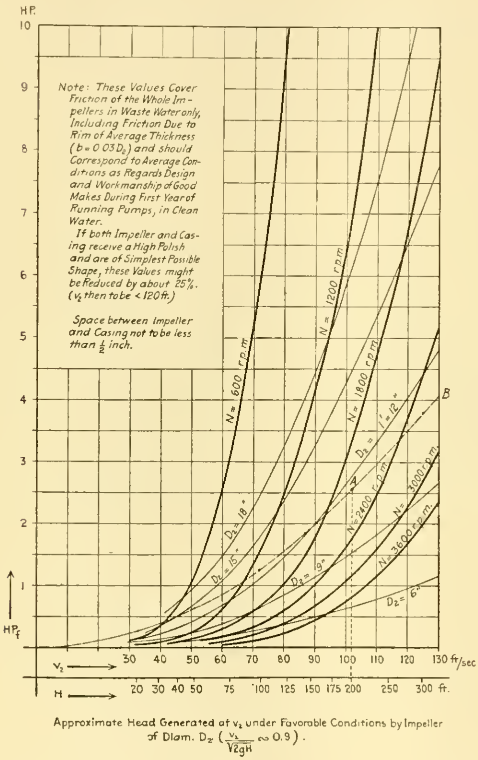


Fig. 6 Loss through Disk Friction in Function of Diameter and Speed, Based on Formulae 12 and 14

and often to more than 10 per cent in high lift pumps, it is evident that the mere changing of the vane angle from 20 to 45 deg. implies a profit of from 3 to 8 per cent and even more in the efficiency of such pumps. The reason why many designers like to choose flat angles of about 20 deg. is that the water then leaves the runner at a relatively high static pressure and low speed, i.e., that little or no attention need be paid to the balance of the kinetic energy. Diffusors or guide wheels may be dispensed with, and eddies due to an improperly simplified design of the casing cannot do much harm. Still, competition in regard to efficiency between various makes and the urgent demand of the salesmen to reduce the motor power in order to minimize the cost of the unit to the consumer gradually force the manufacturer and designer to abandon their preference for flat angles and to utilize the advantage that results from the consequent reduction in diameter and disk friction.

In order to enable designers and manufacturers to estimate the loss due to disk friction without resorting to formula [12] which is rather unwieldy for practical use, the author plotted the diagram Fig. 6, which should be self-explanatory. In basing the chart on the highest values found by Gibson and adding 15 per cent for friction of rim (supposed to be 3 per cent of $D_2$ thick) the author felt he should come nearest to conditions as they obtain in practice.

The author here gives some examples serving to illustrate the value and the mode of using this figure: the following example is a typical one:

Suppose 250 gal. per min. were to be pressed against a total head of 600 ft. and the speed of about 1800 r.p.m. had to be adhered to, say on account of 60 cycle a.c. current motor drive. What number of stages should be chosen?

As 200 ft. per stage is too much for that capacity, either a 4-stage, a 5-stage or a 6-stage pump must be employed. By using Fig. 6 the following table (Table 1) can be compiled without difficulty:

TABLE 1

INFLUENCE OF NUMBER OF STAGES ON PERCENTAGE VALUES OF LOSS THROUGH DISK FRICTION

| $Q$ = 250 gal. per min. $N$ = 1800 r.p.m. | Head per stage in ft. | Water h. p. per stage | Loss through disk friction | |
|---|---|---|---|---|
| | | | In h. p. per stage | In percentage of water h.p. |
| 4-stage pump......... | 150 | 9.5 | 1.62 | 17 |
| 5-stage pump......... | 120 | 7.6 | 0.98 | 12.9 |
| 6-stage pump......... | 100 | 6.3 | 0.66 | 10.5 |

If the 4-stage and the 6-stage pump were designed equally well, the 6-stage pump would have an inherent advantage, due solely to the number of stages, of about 6.5 per cent of the water-horse power, or about 4 per cent in efficiency. The first cost would be increased in proportion to the number of stages, and it would be a question of the cost of energy to the consumer whether the 4 per cent advantage in efficiency would outweigh the excess in price of the 6-stage pump over that of the 4-stage pump.

Looking at the question from the manufacturer's point of view, it might be possible, by abandoning certain niceties in design, for instance, the expensive guide vanes, to turn out a 6-stage pump actually as cheaply as the more elaborate 4-stage pump. If more than 4 per cent of efficiency was not sacrificed by that simplification the 6-stage pump would be as advantageous as the 4-stage pump—leaving out the question of number of spare parts, dimensions and weight.

One more point comes in for consideration: an impeller designed for 250 gal. only and required to pump against a 150-ft. head per stage would have to be large in diameter. As the duty is comparatively small, the passages at its circumference become rather narrow—too narrow perhaps for the cores to be properly fixed in the mould, or the passages to be well filed out in the shops. For this reason alone the head per stage is limited. The admissible minimum number in the present instance is probably 5-stage. The competition then stands between the 5-stage and the 6-stage pump. It is evident that it will be a difficult decision whether the

slight increase in efficiency due to the one stage more will warrant the extra cost of that stage. Leaving out the possible advantages in manufacturing costs which might result from a greater output, a skilful designer may be quite able to surpass the efficiency of a competitive 6-stage pump with a 5-stage pump of like or even lesser cost per stage, though the former has a natural advantage of 2.5 per cent less in disk friction.

At any rate the question will be of such nicety as to make it impossible for the buyer, judging merely from the number of stages, to have a sufficient insight into the merits of a pump. *Specifications, therefore, should not fix the number of stages, but leave this point to the discretion of the manufacturer.*

INFLUENCE OF LATERAL DISTANCE BETWEEN CASING AND DISK

Fig. 7 represents a diagrammatic compilation of the results which Gibson and Ryan obtained when varying the lateral distance, *s*, with those found by Wagner when rotating a disk in practically an unlimited basin ($s = \infty$) and by Dr. Becker when rotating a polished piston within a very narrow polished casing.

From the diagram it is clear that the loss due to disk friction has, in general, a rising tendency with increasing width, *s*, of the waste-water chamber.

Nothing can illustrate better than this diagram the necessity of using every caution in deriving conclusions from any mathematical survey of hydrodynamic problems.

The designer will draw two conclusions from Fig. 7. First, there is in general a tendency for the disk losses to rise when the width of the waste-water chamber is increased.

Second, concentric circular protrusions or ribs are not objectionable and might even be of advantage by breaking the secondary currents; while radial ribs must increase the disk losses because they favor the generation of induced currents and additional losses caused thereby.

INFLUENCE OF LATERAL DISTANCE AND ROUGHNESS UPON THE AXIAL THRUST

Professor Gibson, when investigating the effects of radial vanes attached to the impeller, measured the pressures generated by them. Incidentally he made a few readings from the gage attached for that purpose at the casing (which had an internal diameter of 13 in.) while rotating smooth disks. The author found that these accidental by-products of Gibson's tests are of the utmost importance for explaining and, therefore, mastering some components of the axial thrust which for a long time remained inexplicable to him and to many others.

In Fig. 8 the lower three curves (curves of $h_g$) are plotted from Gibson's results. They represent the pressure difference due to the rotation of the waste-water between the center and points at a radial distance of 6½ in. from it.

From these readings it is possible to work out the rotary speeds of the waste-fluid, $N_T$, which, for the particular value of $r = 0.541$ ft. obtaining in Gibson's apparatus, is

$$N_T = 215\sqrt{h_g}$$

By far the most important consequences follow from Fig. 8 when used to estimate what axial pressures will result if the roughness of disk or casing, or their distance from each other, differ on the two sides of the impeller.

Equation [10] furnishes the total axial force resulting from the coöperation of the static pressure $h_s$ generated by the impeller vanes at the circumference, and the gyrostatic pressure $h_g$. If the rotary speed of the waste-water $N_T$ is different on the two sides of the same impeller an axial thrust results. This thrust is most striking with so-called balanced impellers, i.e., either double inlet runners, or runners having a slip ring on the back and borings leading from the inlet chamber through the eye into the chamber thus formed on the back (see Fig. 9). It shall be supposed that the static pressure generated by the impeller vanes is identical on both sides of the impeller. (This does not exactly hold true for single-inlet impellers for reasons which have no bearing upon the problem treated in this paper.)

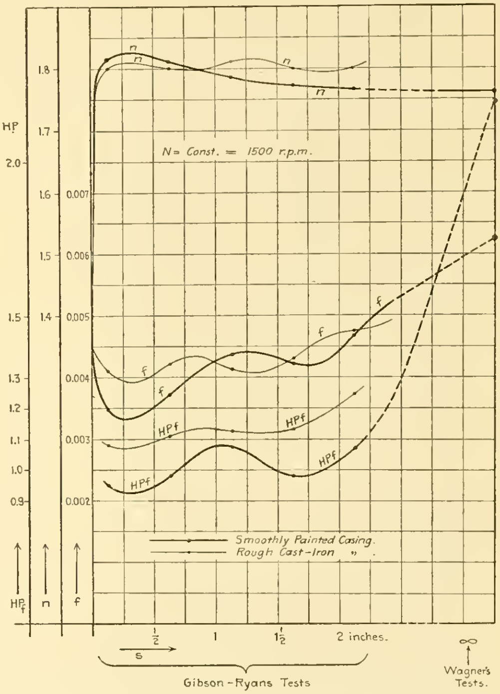


FIG. 7 INFLUENCE OF LATERAL DISTANCE BETWEEN CASING AND POLISHED 12-IN. DIAMETER DISK

When making the above assumption $h_s$ (see equation [10]) is eliminated when subtracting the total axial force on one side from that on the other, and the effect of the gyrostatic phenomenon can be treated independently of any other causes which might affect axial thrust.

After subtracting the two values which equation [10] assumes for two different rotary speeds of the waste-water bodies on both sides of the impeller, the following equation results:

$$P_{s-s'} = P_g - P_g' - \frac{4.25\times 49}{100000}(D_2^2 - D_1^2)D_2^2(N_T^2 - N_T'^2) \quad [25]$$

Introducing the values for $P_g$ and $P_g'$ which result from equation [9] this final expression is obtained for the differential axial force:

$$P_a = PL_{6-6'} = \frac{N_T^2 - N_T'^2}{1000}\,[2.08\,(D_2^2 - D_1^2)D_2^2 - (D_2^4 - D_1^4)] \ldots\ldots [25_a]$$

where

$N_T$ and $N_T'$ = r.p.m. of waste-water bodies on two sides of impeller.

$D_2$ = outer diameter of impeller in ft.

$D_1$ = diameter of clearance of slip-rings in ft.

$P_a$ = axial thrust resulting from difference between $N$ and $N_T'$, in lb.

$P_a'$ depends on the fourth power of the diameter. No appreciable inaccuracy is caused by disregarding the central part of the impeller.

Fig. 9 shows the direction of the resulting thrust $P_a$.

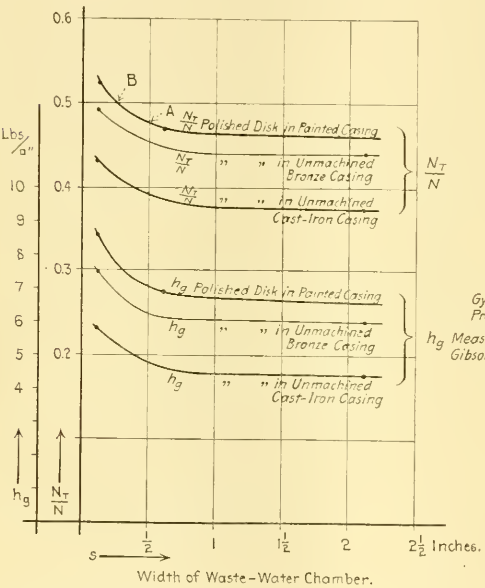


Fig. 8 Rotary Speed and Pressure in 13-In. Diameter Casing Produced by 12-In. Diameter Disk Running at 1200 r.p.m., in Function Width of Waste-Water Chamber

The difference in pressure between axis and periphery is greatest where the waste-water rotates quickest (Fig. 9; right hand side—owing to small distance $s$). The static pressure $h_s$ is the same on both sides. On the side where the waste-water rotates faster the gyrostatic pressure cuts out a greater parabolic area than at the other side. Therefore the total weight of pressure is smaller on the side where the waste-water rotates faster. Perhaps the following rule is easier to keep in mind: *"The impeller is drawn to the side where the waste-water rotates fastest."*

Two more examples, intentionally chosen to emphasize the necessity of the designer's attention to gyrostatic axial thrust, are here worked out in the paper. They show that an axial thrust of 440 lb. can be easily accounted for by the gyrostatic pressure differences forming in a 4-stage pump with impellers 1 ft. in diameter and the lateral width of the waste-water chambers ½-in. on one and ¼-in. on the other side of each impeller. Mention is made that further investigation of the details of the curves in Fig. 8 would be very desirable.

The gyrostatic axial forces, though important, do not constitute the only hidden cause of axial thrust. There are other variable components of the axial forces due, for instance, to the flow of the leakage water, or to the difference in pressure within the cells of the impeller, etc. Designers may never hope to obtain perfect balance under more than one particular condition or independent of wear and tear. They must always rely upon some strong hydraulic balancing mechanism or thrust bearing. The value of the above formulæ, therefore, lies principally in the possibility to foresee, by their aid, any danger that the axial thrust of the pump may act in the direction opposite or in addition to that for which the balancing device or thrust bearing is designed. It is known what strong axial forces can be exerted

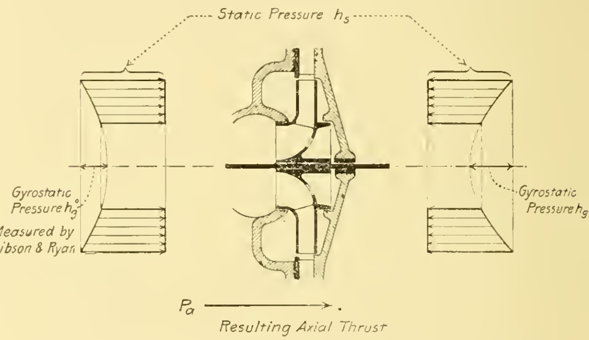


Fig. 9 Diagram Indicating Axial Thrust Due to Effect of Rotation of the Waste-Water

by disks provided with radial ribs. In this connection the results which Professor Hesse derived from investigating hydraulic footsteps offer some valuable data to the designer, as does the paper of Gibson and Ryan. Not so well known, but no less remarkable is the effect of radial vanes in the fixed walls of the waste-water chamber. From the mathematical survey in Section II it is evident that their effect must about equal that of rotary vanes. The author knows of the experiences of a well-known pump manufacturer who had provided radial ribs in one, but not in the other waste-water chamber of a perfectly symmetrical double inlet impeller. The strong axial thrust which resulted was reduced to almost nil after the pockets between the ribs were covered by means of sheet iron, and incidentally the efficiency was considerably increased.

In case a designer should find it difficult for general constructive reasons, to shape both waste-water chambers exactly alike, he will, on the basis of the information contained in this paper, be able to counterbalance the effect of any differences in roughness and shape. It is scarcely necessary for the author to elaborate on this question which must be solved in a different way in each individual case.

## DISCUSSION

C. George de Laval. The author draws the conclusion that effect of roughness of surfaces on impellers and internal parts does not to an appreciable degree affect the efficiency of the pumps. In late reesarches by the National Physical Laboratory in England, it has been shown that the change from lamellar motion of liquid to eddying motion takes place suddenly at a definite value of the critical velocity and which is directly proportional to the kinematical viscosity of fluid. The conclusions by Lord Rayleigh indicate that, by the principle of dynamical similarity, the relation of bodies immersed in fluids moving relatively to them is a general law of resistance of bodies and depends on the velocity, density and kinematical viscosity of the fluid expressed by the formula

$$R = \varrho v^2 F \frac{(\mu d)}{s}$$

Where $d$ = section or diameter of casing or pipe

$R$ is resistance per unit area

$S$ = specific gravity

$F$ is a function of the one variable $\frac{\mu d}{s}$

$\varrho$ = density of water

$v$ = mean velocity of water

$\mu$ = viscosity

The information given by the author is exceedingly interesting, particularly in the light thrown on fluids affected by viscosity, temperature and specific gravity. There is no doubt that little is known of this, not only on movement through pipes but also in chambers of centrifugal pumps. It is, no doubt, difficult to obtain a practical formula for use in dealing with very viscous liquids, nor can one estimate even approximately what can be expected in the way of power, speed and capacity.

The writer has found that results obtained are at considerable variance with what has been expected from mathematical conclusions based on existing laws of water. It would be most helpful if a commission were appointed to conduct a series of experiments to determine frictional resistances of oil and heavy viscous liquids in pipes, centrifugal pumps and reciprocating pumps and so finally establish a practical formula which could be relied upon. The oil industry is so great and important that more research information should be made available to the engineering profession than is now. Today we have not even a standard viscometer which is satisfactory; nor is a final method settled upon as to basis of figuring results and comparing with water.

The guaranteed performance of a centrifugal pump for oil is always based on clear water, the friction of oil in pipes and pump being assumed on this basis. The final results in pumping oil with a specific gravity of 0.87 show an increase of power of about 20 per cent and a reduction in head of about 20 per cent. The internal disk friction of impellers on account of viscosity of the oil causes the efficiency to drop 25 per cent. Theoretically the pumping head, whether oil or water, should be the same, but owing to the viscosity of the liquid there is considerable heat generated by the impellers in the pump chamber and the friction loss of the liquid increases, due to the viscosity in impeller passages, so that the head produced is about 20 per cent less than with water. It is, therefore, necessary that experiments are resorted to as a considerable number of errors will creep in and give misleading results.

The author claims that he answers these important questions by theory without resorting to experiments. To the writer this appears a rather dangerous proceeding as to influence of viscosity, temperature and specific gravity of fluids on disk friction. Theories should be proved out by experiments. The work wasted in impeller friction, which is a wasted power due to skin friction, is the most serious loss and can be obviated by having the impeller revolve in atmospheric air, sealing the edges of outer circumference of impellers at each side of the rim and also at hub; this would go a long way towards increasing over-all efficiency and reduce the power. Any leakages at these points can be automatically taken care of, allowing this water to go back to its original source, the amount of which would be very small.

Impellers could be made also to operate in air pressure between impeller and casings. Both these methods would reduce the skin friction, gyrostatic and axial losses. Credit is due the author for bringing these subjects before us and his studies of the subjects give us considerable information on these important losses, about which there is very meager and incomplete information.

M. D. Hersey. In order to be able to state that an equation is wrong because it is not dimensionally homogeneous, it is necessary that all the physical quantities which govern that fact must be included in the question of the equation; hence, while the noteworthy use which the author has made of this criterion, both in refuting Rossiter's equation and in developing his own results, is entirely legitimate, it is to be remembered that, in other cases likely to arise in hydraulics, if some physical quantity, such as gravity, has been suppressed, an equation not dimensionally homogeneous may still be correct.

The Author. When the surface of an impeller is covered with sediments equalling the structure of fine sand, the friction loss may increase to three times its value with polished surfaces, or twice that prevailing when the disk consists of a smooth casting. However, such degree of roughness may safely be termed abnormal in turbine pumps, and the loss caused by an ordinary smooth impeller in most pumps is not so much greater than that caused by a polished disk that it pays to polish the impeller faces, especially as they soon lose their polish when running.

As to the influence of eddying and lamellar motion, it should be emphasized that unless the speeds of the pumped fluid are high enough to insure eddying motion throughout, the ordinary centrifugal pump is not fit to pump. The papers presented by Messrs. Buckingham and Hersey at this meeting deal more closely with the problems touched by Mr. de Laval.

The suggestion to entrust a special commission in this country with the experimental work on viscosity is an excellent one. The author intends to direct the attention of the U. S. Bureau of Standards to the advisability of establishing more firmly the standards and laws of viscosity. He would be glad indeed to have Mr. de Laval coöperate in this motion.

Mr. de Laval very aptly draws attention to the effect which the heat developed by impeller friction must have on viscosity. The author, however, has not committed the mis-

take imputed to him—that of resorting to theoretical rather than experimental solution of the question of the influence of viscosity, temperature, and specific gravity of the fluid. As a matter of fact, he resorted to dimensional reasoning in this instance only after very carefully investigating all available experimental evidence.

After the paper was written, the author applied formula [23] to some other tests carried out with syrup of known viscosity, gravity and temperature, and found that the calculation tallied very well indeed with experiment. The figures are at Mr. de Laval's disposal.

Unfortunately the figures quoted by Mr. de Laval are not conclusive, as he does not state the value of the coefficient of viscosity of the oil which he pumped. This, by the way, is a figure which pump-makers are almost never able to obtain from customers, but without which they are entirely unable to predict results.

The idea of trying to rotate the impeller in air instead of water is not new. The author has himself given it a considerable amount of thought which he condensed in his application for German patent, No. N. 11099. There also are some French and American patents covering similar efforts. The practical difficulties which stand in the way of this idea, however, are very great indeed. How, for instance, is it to be avoided that the impeller should suck air from the lateral chambers?

At present those high lift impeller designs which tend to diminish the diameter of the impeller, i.e., to diminish the impeller coefficient, deserve more attention. The reduction in disk friction loss is about five times the percentic reduction of this coefficient.

The point raised by Mr. Hersey will be treated in my discussion of this gentleman's paper.

# A BASIS FOR RATIONAL DESIGN OF HEAT TRANSFER APPARATUS

E. E. WILSON, NEW YORK

Non-Member[1]

An examination of the literature on the subject of heat transfer shows such a wide variation in the coefficients established that it is difficult to make a choice for use in practice. The fact that the results of careful experimenters do not agree leads to the conclusion that some variable or variables have been neglected, and the fact that the rate of heat transfer in feed water heaters is consistently greater than that in the similar apparatus, the condenser, indicates that one such neglected variable is the temperature of the circulating water. It is the purpose of this paper to apply a correction for the water temperature to the results of reliable experiments.

By correcting for all variables, the rate of heat transfer which is generally expressed as some exponential function of the circulating water velocity, may be expressed in a different form as a straight line function. With this relation it is possible to evaluate the thickness of a water film capable of offering the same resistance to heat transfer as is encountered on the water side of a condenser or feed water heater. From the known internal conductivity of such a film it is possible to develop an expression for the area of heating surface required to transmit a given quantity of heat under all conditions of circulating water velocity and temperature, mean temperature difference, and tube diameters. With the use of suitable design factors this expression for area may form the basis of rational design, while a consideration of the manner in which the variables appear may be of assistance to the operator.

The possibility of solution along the lines indicated was brought to the author's attention by Dr. C. E. Lucke of Columbia University.

In condensers and feed water heaters the resistances to heat flow for clean tubes are:

*a* That due to the thickness of the tube walls.

*b* That due to the film of water on the steam side next the tubes.

*c* That due to air in the exhaust steam.

*d* That due to the water film on the water side.

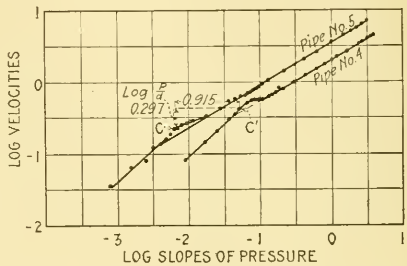


Fig. 1 Variation of Loss of Head in Pipes as Reported by Osborne Reynolds, Philosophical Transactions of the Royal Society of London, 1883

Under ordinary conditions of operation (*d*) will be the controlling resistance and any increase in heat transfer should come through reduction of the film thickness on the water side. This is evident when the general law of heat transfer is considered. Taking the analogy of the electric or magnetic circuit we may write,

$$U = t_m \div R$$

in which

$U$ = B.t.u. transmitted per hour per sq. ft.

$t_m$ = mean temperature difference between the hot and cold fluids

$R$ = resistance to transfer

Putting in the individual resistances enumerated above this becomes

$$U = \frac{t}{R_w + R_a + R_s + R_t}$$

in which

$R_w$ = resistance of the water film on the water side

$R_a$ = resistance of the air film on the steam side

$R_s$ = resistance of the water film on the steam side

$R_t$ = resistance of the tube walls.

If $\rho$ be the resistance per unit of film thickness and $l$, the thickness of the film the expression becomes

$$U = \frac{t_m}{\rho_w l_w + \rho_a l_a + \rho_s l_s + \rho_t l_t}$$

[1] Lieutenant, U. S. N.

Presented at the Spring Meeting of the Society, June 1915. Complete paper may be obtained without discussion; price 10 cents to members; 20 cents to non-members.

in which we have the heat transfer in terms of the film thicknesses involved.

Considering now the controlling resistance, that on the circulating water side, we find that this decreases as the water velocity increases. Just how it decreases has been the subject of much investigation and the results have been summed up by G. A. Orrok[1] in his paper.

In his Scientific Papers, Osborne Reynolds pointed out that if a fluid traversed a tube without turbulence, the resistance to the transfer of heat would be entirely independent of the velocity; while, if the flow were turbulent, it would vary inversely as the velocity. In a later paper he showed that the transition from non-turbulent to turbulent flow was a discontinuous phenomenon: on a certain critical velocity being exceeded, turbulence abruptly sets in. Hence, when heat is being transferred from a hot tube to a fluid flowing in it, the law of heat transference changes abruptly once the critical velocity is reached.

The critical velocity according to Reynolds is given by the relation

$$V_{\text{critical}} = \frac{1}{B} \cdot \frac{P}{d}$$

where

$P$ = Poiseuille's value for the ratio of viscosity to density

$d$ = internal diameter of the tube.

$B$ = a constant

The value of $P$ in centigrade units is given as

$$\frac{1}{1 + 0.0336T + 0.000221T^2}$$

in which $T$ is the absolute temperature centigrade.

If now the value of $P$ at some one temperature, such as 60 deg., be settled upon as the standard, the ratio of $P$ at any other temperature to that at the standard temperature may be computed as a specific viscosity.

The view that the rate of heat transfer should vary inversely with the viscosity was arrived at through consideration of the similarity between the accepted law for heat transfer and that for the loss of head in pipes. Reynolds found that up to the critical velocity the loss of head varied directly with the velocity as shown in the lower branches of two of his results in Fig. 1. The coördinates here are the logarithms of the loss of head and velocity, and the slope of the lower branches is 45 deg. At the critical points $C$ and $C'$ the flow becomes turbulent and the slope of the curve changes to about 1.72. Reynolds shows further that the temperature of the water and diameter of the tube have little or no effect upon the slope of the curves but that these may be shifted so as to be exactly coincident. The component of this shift in the direction of the velocity is 0.297 on the figure and this corresponds very closely to log. $P/d$ in the expression for critical velocity above.

With these facts in mind the results for heat transfer were investigated and those reported by Orrok were selected as being the most complete and accurate. The mean temperature of the circulating water was computed from his factors of correction for viscosity and the data grouped in accord with certain average temperatures. The results are plotted in Fig. 2 from which it is seen that there is a distinct shift from the mean of the points for the lowest temperature to those of the highest temperature. Of course these results are too few and, not having been obtained with this purpose in mind, are too inaccurate for quantitative results, but they show well enough the qualitative effect.

[1] Trans. Am. Soc. M. E., Vol. 32, p. 1139.

The points defining the five lines of more or less equal temperature form a wide band. If, however, we apply a correction similar to that for the critical velocity so as to reduce the results to some common temperature, say 60 deg., the width of this band is cut in half. For instance, if the mean water temperature in one case were 40 deg. and the velocity 5 ft. per sec., the resistance to heat transfer would be the same as if the temperature were 60 deg. and the velocity

$$\frac{5 \times P_{60}}{P_{40}} = 3.62 \text{ ft-sec.}$$

This correction has been applied and the results as reduced from a 1-in. to a ⅝-in. pipe are plotted in Fig. 5 along with the uncorrected data. The reduction in the dispersion

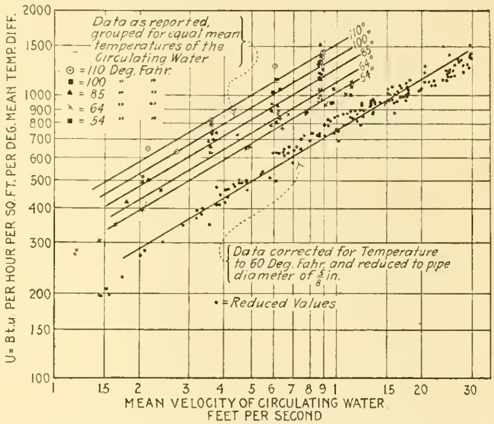


Fig. 2 Rate of Heat Transfer versus Circulating Water Velocity. Results of Tests by Orrok, Trans. Am. Soc. M. E., 1910

is quite marked and the agreement, in view of the difficulties in eliminating air from the steam in a test of this sort, becomes now quite good. There is a tendency toward curvature in the plots but this is not well enough defined to permit of revaluation owing to the scarcity of points at the low velocities.

By further reasoning it is found that there is a linear relation between the resistance on the water side and one variable, the velocity, after the other variables have been taken care of in reducing the velocity. The resistance of the tube walls for clean tubes is well known and that on the steam side has been determined for the one case, that of steam at 212 deg. The curves resulting from plotting experimental data will lie above that due to the sum of the resistance as calculated, because in practice steam is never quite air free and the resistance on the steam side is increased by that due to the air.

This constitutes the reduction for viscosity, but when the results of different experimenters are considered it is found that different sized tubes have been used.

But

$$\varrho\omega = Rw \times \frac{\text{Inner diameter}}{\text{Outer diameter}}$$

$$(Rw)_1 = (Rw)_{5/8} \times \frac{1.00}{0.902} \times \frac{0.529}{0.625} \times \frac{0.529}{0.902} = 0.55\,(Rw)_{5/8}$$

gives a reduction factor for relating the two sizes of tubes on the basis of the resistance of the water.

As an example of the method of applying the corrections for working up the results, take the first run in Orrok's results. Here $V_w = 11.2$ ft. per sec.; $t_s = 126.3$ deg.; $t_m = 73.2$ deg.; $U = 1000$. Now $t_s - t_m = 54.1$ deg. From the table of correction factors, Table 1, $C = 1.10$. Then

$$V_{60} = \frac{11.2}{1.10} = 9.3$$

$$V_{\text{final}} = V_{60} \times \frac{0.902}{0.529} - 9.3 \times \frac{0.902}{0.529} = 15.9$$

of which the reciprocal is 0.063. This can be raised to the 0.82 power by laying off a pair of scales, one of which will show $V$ when the other gives $V^{-0.82}$. By this method the result is 0.102.

$$R = 1000 \times \frac{1}{V} = \frac{10{,}000}{1000}$$

or in this case, 1. The coördinates of a point on the final curve are then 1 and 0.102.

It is not absolutely necessary, as has been done so far, to deal with these resistances in terms of an arbitrary unit, since the resistance may be expressed in terms of the thickness of equivalent water films, by a simple transformation. When this is done we have the thickness of the films on each side and that of the tube wall expressed as a water film thickness, and we have the film thickness on the water side in terms of one variable which has been reduced in such a manner that all other variables are accounted for. In other words, we have a linear relation between the physical object offering the resistance and the factors upon which it depends for its magnitude.

It now remains to express the results algebraically and this may be readily done. Since the curves are of the form $y = mx + b$ we have, measuring the values of $m$ and $b$ on the line for "resistance as measured" in Fig. 3,

$$l = 0.0143 \left(\frac{1}{V_{60}}\right)^{0.82} + 0.00313$$

Now the reduced velocity $V_{60}$ was corrected for both viscosity and the diameter of the standard 5/8-in. tube, 0.529 in. If we let $d$ be the inside diameter of the tube under test and $Pt$ be the viscosity ÷ density for the mean water temperature as before and $P_{60}$ the same ratio for the standard water temperature we can write

$$l = 0.0143 \left(\frac{P^t \times 0.529}{V \times P_{60} \times d}\right)^{0.82} + 0.00313$$

Calling the ratio of the viscosities $C_w$, water correction, and reducing we find

$$l = 0.0085 \left(\frac{C_w}{V \times d}\right)^{0.82} + 0.00313$$

If now $C_w$ can be expressed in terms of the temperature we have an expression involving the film thickness and all the variables concerned. In Fig. 4 the values of $C$ have been plotted against absolute temperature in deg. fahr. on logarithmic paper, and it is seen that while the curve is not exactly straight it can be divided into two sections which are practically so. The lower section has a range from 32 to 140 deg. fahr., which embraces the temperatures met in condenser practice and greatly exceeds the limits in this practice. Expressing the lower section algebraically we have

$$C_w = \left(\frac{520}{T_w}\right)^{6.57}$$

From which, and the expression for $l$ above

$$l = \frac{34.0 \times 10^{12}}{T_w^{5.38} \times (V \times d)^{0.82}} + 0.00313$$

For water temperatures outside this range, such as those met in feed water heaters, the upper section may be used and a similar expression obtained.

This expression is a rational one as far as film thicknesses are concerned but is still not in a practical form. To reduce

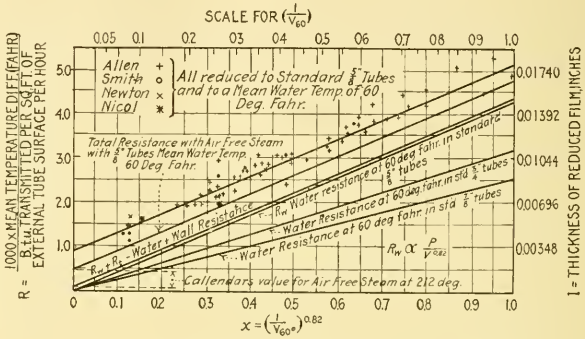


Fig. 3 Resistance to Heat Flow in Terms of "Fully Reduced," Velocity of Circulating Water. Engineering, Jan. 23, 1914

it to such form, the general law of heat transfer is utilized. According to this law

$$Q = AUt_m$$

in which $Q$ is the heat transferred per hour, $A$, the area of the heating surface, and $t_m$ the mean temperature difference as before.

Remembering that we can now write

$$U = \frac{1}{\varrho l},$$

$$A = \frac{\varrho l}{t_m}$$

from which

$$A = \frac{Q}{3.48 \times t_m}\left(\frac{34 \times 10^{12}}{T^{5.38}(V \times d)^{0.82}} + 0.00313\right)$$

Upon further reduction this becomes

$$A = \frac{Q}{t_m}\left(\frac{976 \times 10^{10}}{T^{5.38}(V \times d)^{0.82}} + 0.0009\right)$$

This is a rational expression for the area of the heating surface required in a condenser in which all the surface is active and in which steam is substantially air free, as it exists when an effective dry vacuum pump is in use.

The above rational expression for the area of condensers, the determination of the actual thickness of the dead fluid film and its variation with the flow conditions, suggests a method of dealing with all heat transfer apparatus, dependent upon the same principles.

*Conclusions.* In condensers and feed water heaters, using

practically air free steam, the controlling resistance to heat transfer is on the water side. This resistance is a function of the water velocity, its mean temperature and the diameter of the tubes, and it varies inversely as these three variables, according to a straight line law. Large quantities of air collecting in pockets on the water side greatly increase the resistance to heat flow while the quantity of solid matter contained in the circulating water may increase the apparent resistance by increasing the apparent velocity as determined by the weight of water passing. The viscosity of the circulating water has an important influence on the resistance, since the warmer the water the less resistance it offers. The resistance due to oily circulating water may be greatly different from that of fresh water. Finally by analysis of reliable test data it is possible to get an expression for the area of heating surface required to transmit a given quantity of heat, in terms of prime variables, from which it is seen that the area varies directly as the quantity of heat to be transferred per hour per square foot, and inversely as the circulating water velocity and its mean temperature, as well as the tube diameter. Such an expression, based on good experimental results, should replace empiric coefficients in design and assist materially in operation.

## DISCUSSION

Robert C. H. Heck stated in a written communication that the argument is developed so much by the experimental method that the title "rational" seemed to him to be fully deserved. The argument from analogy between the law for heat transfer and that for the law of head in pipes appeared to him to be rather far-fetched, the functions used not being really enough alike in their manner of variation to warrant such an assumption. Besides, the assumption that general velocity states are proportional to critical states is not yet proved. He could not accept the assumption that because, with the same water temperature, the critical velocity in a 1-in. tube is only one-half as great as in a half-inch tube, therefore the unit surface of the larger tube is twice as effective as the unit of the smaller tube. The idea of complete inverse proportionality to temperature appeared to be too simple and not yet proved experimentally. He believed that the difference of slant in the final line of Fig. 7 and 8 was due more to excessive influence of tube diameters than to the causes named by the author.

Leo Loeb objected to the fundamental conclusion of the writer that the control resistance to heat transfer from the condensing vapor to liquid warming rests on the liquid side and that the numerical value depends on the three factors of water velocity, mean temperature and tube temperature. Recently types of apparatus have been produced in which the agitation of the liquid is carried to the highest practicable point consistent with reasonable frictional resistance and it appears that in the near future the largest part of such apparatus will embody construction principles which will make it altogether impossible to base results on either velocity or temperature.

Variation in results reported by several investigators may be due to lack of standard methods of tests and of uniformity in the presentation of data as well as, in some instances, to an improper conception of the meaning and application of the term "temperature difference." Thus accidental errors may be due to difference in temperature across the cross section of a pipe where the outlet temperature is measured. Several instances have shown that water is discharged from different portions of the heating surface in streams of varying temperature and that these streams did not diffuse readily.

He objected to the assumption generally made that the law of heat transfer is analogous to that of an electric or magnetic circuit which it can be only when there is under consideration a single thermal resistance, a case which never occurs in practice.

He further discussed his own tests conducted at the Naval Engineering Experiment Station upon single tubes and normal heaters (Published in the Journal of the American Society of Naval Engineers, May, 1915; compare abstract in The A.S.M.E. Journal, August, 1915), and their bearing on the theory presented by Lieutenant Wilson.

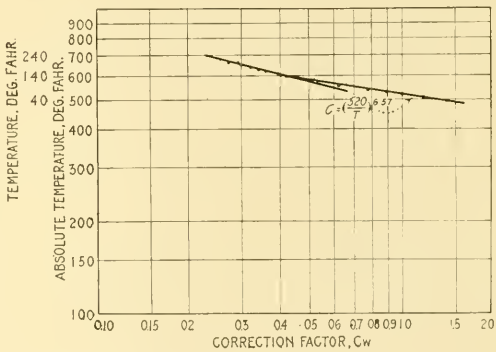


Fig. 4 Curves of Correcting Factors for Variation in Viscosity due to Temperature of Condenser Circulating Water

H. Wade Hibbard made a plea that whenever mathematical papers are presented before the Society the authors use footnotes showing how they have evolved their equations, in the most elementary fashion. He had observed that mathematical papers presented before the Society in years past had received scant discussion, due in part to the jumps in the mathematics in the papers.

The author mentions that "The controlling resistance to heat transfer is on the water side," showing how much emphasis he places upon the word "controlling." In condenser practice we have rain plates so that the moisture will be removed from the tubes as quickly as possible and the steam which follows will strike against tubes that are not encased in wet film.

Edgar Buckingham contributed a written discussion of the physics of the subject of heat transmission, in which he showed that the heat transmitted to the liquid from unit length of the tube in unit time could be expressed by an equation of the form

$$Q = DV\rho C\Delta\Phi \left\{ \frac{DV\rho}{\mu} \cdot \frac{V^2\alpha}{C} \cdot \frac{\mu C}{\lambda} \cdot \alpha\Delta \right\}$$

where

$D$ = internal diameter of tube
$V$ = speed of fluid
$\rho$ = density of fluid
$\mu$ = viscosity of fluid
$C$ = specific heat of fluid
$\Delta$ = temperature difference
$\lambda$ = conductivity at mean temperature of section
$\alpha$ = temperature coefficient of conductivity between this and temperature of inner surface of tube
$\Phi$ = an unknown function which remains to be determined.

This equation shows that a complete investigation of the problem of heat transmission, even for a single liquid in so simple apparatus as a condenser tube, is rather complex. To determine the value of $\Phi$ it is necessary to find the effect on $Q$ of varying four arguments of $\Phi$ separately. In view of our almost complete ignorance about the thermal conductivity of water, to say nothing of other liquids, it is not surprising that we do not yet know all there is to know about heat transmission; and any attempt to proceed rationally, as Lieutenant Wilson has done, by taking into account and allowing for the various physical quantities that may be involved in the process of heat transmission is very much to be welcomed.

Arthur M. Greene, Jr. I would like to ask the author how he proposes to get the mean temperature so as to use the results of his work, and also how he got the mean temperature which he did use.

As Mr. Braun points out, if he uses the arithmetic mean or the logarithmic mean, he gets two results; and if the viscosity is affected by the temperature he has got to consider that fact in finding the coefficient of heat transfer. It seems that both of those methods in getting $t_m$ are incorrect and you have really to find $t_m$ by the method that Orrok uses in his work on the condenser.

I would also like to say that Mr. Leo Loeb's paper, which recently appeared in the Transactions of the Institute of Naval Engineers, clearly points out the fact that this heat transfer coefficient varies with the temperature. The method he uses is rather unique, and proved clearly, I think, that we must use some exponent form for the computation of $T_m$. If we do this it seems to me better than to use an expression involving viscosity.

C. F. Braun. This paper is particularly interesting to the writer because it treats in a most thorough manner a factor in calorifier design, which is given only slight attention in my condenser paper.

Unquestionably the resistance to heat flow on the fluid side of a tube increases rapidly with increase in viscosity and is a most important factor in the design of calorifiers for such viscous fluids as oils, syrups, etc., having viscosities ranging up to 50 times that of water. As the oil industry particularly is an important one in this country and the demand for oil heaters and exchangers large, the development of rational formulae relating to heat transfer and viscosity would be very valuable, and can the author extend his researches to these fields he will render a service to the profession.

The viscosity of water varies so slightly within the ranges of temperatures encountered in heater and condenser practice that its effect, I feel, is almost negligible compared with that of other variables indeterminate and difficult to control. I am a great believer in figuring, but we must eliminate unimportant complications, or we avoid and do not use our theory.

One of the greatest variables in determining the unit coefficient of heat transfer for comparison of different experimental results is the method of computing the mean temperature difference. Without discussing the merits of the various formulae, it is sufficient to call attention to the fact that the arithmetic mean, logarithmic mean and others produce widely varying results, particularly when the ratio between the least temperature difference and the greatest temperature difference is small.

Again the amount of air present is a variable which cannot be controlled or its effect determined, and will invariably produce variations far beyond the limits of viscosity effects.

The density or mass flow of the steam, while apparently having no important effect upon heat transfer, may very probably have as much if not more effect than the viscosity of the water.

I also thoroughly believe that heat transfer varies inversely with tube size and to a far greater degree than with water viscosity. Experimental data on this point would be valuable.

Unaccountable discrepancies in condenser test results are very frequently the result of assuming a uniform temperature in the steam space, instead of obtaining an average which may fall considerably below that at the inlet, due to frictional pressure drop through the tube of space, and to the presence of air.

The Author. Professor Heck criticises the reference to the similarity between the laws of resistance to the flow of water and heat on the grounds of dissimilarity of exponents. The mere numerical value of these exponents is of little importance for the purpose in hand. It was the similarity in form of the accepted law that led to the study, and although this study showed the exponential law to be incorrect for heat transfer, nevertheless the remarkable facility with which all data are reconciled by the viscosity correction is justification enough for the method.

Professor Heck also objects to the use of the word "rational." My understanding of the meaning of this word as applied to an equation is that an expression is rational when it so involves the different variables that the truth may be checked up by the fundamental dimensional equations. Doctor Buckingham's very interesting paper treats of that same subject. Taking the expression for film thickness in the paper we have,

$$L = \frac{a}{V} \div b$$

where $L$ is the thickness, $V$, the reduced water velocity, $a$, the slope of the line, and $b$, the intercept on the vertical axis, Figs. 7 and 8. In this expression $b$ has the dimension $L$; $V$ is of course $L/T$; $a$ is $L/V$ or $L^2/T$, and we then have

$$L = \frac{L^2T}{TL} \div L = L$$

which is a rational expression. Referring to the expression for the area we have

$$\frac{A = Q\rho L}{t_m}$$ in which $L_/$ is taken as the expression above, by definition $Q/t_m = U$, and $P = L_/ U$ from which

$$A = \frac{UL^2}{U} = L^2$$

which expression is again rational.

As for the influence of the tube diameter to which Professor Heck takes objection, there seems no reason for endeavoring to find a more complicated function. The resistance to heat flow and water flow are both a function of the water agitation. In the flow of water the diameter is shown by Reynolds to have a certain influence on the critical point, that is the point at which the flow becomes turbulent, and this feature in turn affects the resistance to flow. It seems not unreasonable to expect the diameter to have the same sort of influence on heat transfer, which is dependent upon the agitation in the same manner. In comparing a half inch and a one inch tube as to the effectiveness of the unit surface it must be borne in mind that for the same linear velocity the quantity of water passed increases as the square of the diameter. If now the flow is turbulent, there can be a larger number of impacts on the unit surface of the larger tube than of the smaller, and this accounts for the greater effectiveness.

Professor Greene has asked the method of obtaining the mean water temperature. This is shown in the tables where I have subtracted the mean temperature difference $t_m$ from the temperature of the steam $t_s$, thus getting $t_w$, the mean water temperature. Both Mr. Braun and Professor Greene have discussed the mean temperature difference. I am aware of the difference of opinion as to the proper way of getting this. Mr. Orrok in his calculations used the arithmetic mean for the reason that the difference in results by different methods when the temperature rise is small is not worth considering.

Mr. Loeb states that no useful purpose can be served by considering the high circulating water temperature in design where space and weight are limited. On the other hand this seems to me to be the very place careful design is needed. As an example take the condenser design of a battle cruiser developing say 120,000 horse power, on a small displacement. Her condensers will be beyond the limits of present practice so that no comparison may be had with other vessels, yet, on the other hand, space will be so confined as to preclude guess work. Surely accurate design is needed here.

Mr. Loeb calls attention to the fact that the variation in results reported by several investigators may be due to experimental errors, rather than the neglect of the variables mentioned. I appreciate fully the difficulties of work in this field and drew Fig. 9 as an example. My point is that the wide variations in the results of so excellent an investigator as Mr. Orrok are not explained by experimental errors but by neglected variables instead. When in Fig. 5 of the paper I corrected his results for temperature, they became reconciled to a point where further difference might be assigned to experimental inaccuracies.

The objection by Mr. Loeb that the analogy of the law of the electric circuit can apply only when we have a single resistance is not sustained. We are fully justified in writing such a law if we remember that the resistance in this case is a variable. Mr. Loeb practically uses the same analogy in his paper, but instead of separating the resistance into its component parts he assumes that he is keeping this constant when he maintains the water velocity constant and determines an exponent for the mean temperature difference. In the general expression,

$$U = \frac{t_m}{R_w + R_s + R_a + R_t}$$

$R_w$ is not dependent upon the velocity alone, but also on the mean water temperature, and his failure to consider the temperature is probably responsible for the value of his exponent for $t_m$, and its difference from unity. Any exponential law for heat transfer involving either $V$ or $t_m$, however convenient it may be for the design of a limited class of apparatus, cannot be considered a valid general law. As Mr. Loeb says any one can run a few tests and use them as a basis for design for similar apparatus involving the same conditions. Surely, however, we are not entitled to use these few results in writing a general law for the whole subject. Mr. Loeb, in his paper, has developed in a novel manner an excellent method of designing certain types of apparatus, but these same data could not be extended to other types.

The objection that new types of apparatus have been evolved in which agitation is carried to the limit so that viscosity need not be considered, is hardly valid. We have two distinct methods of reducing the resistance, mechanical agitation and increased water temperatures. In certain types of apparatus the first method is carried to the limit, but this does not remove the influence of temperature on the thickness of the water film.

In regard to the value of the exponent of $V$ in the paper, there is no connection between this exponent and that used for $t_m$ by Mr. Loeb in his article. The value 0.82 was settled on by the author of Fig. 7 in *Engineering* apparently by trial. I have since plotted the results of Mr. Orrok's work against $V$ with the index unity and find excellent accord. Further experimental work must determine the real value of the exponent.

In conclusion I want to point out that successful design of heat apparatus has been done empirically and will continue to be so done. In all design, however, we must appreciate two great classes, (1) Functional Design and (2) the Design of the Mechanism. Mr. Braun in his paper gives an excellent summary of the design of the mechanism of a condenser. My paper is intended to demonstrate a basis for rational functional design of heat transfer apparatus of all types for every flow condition, throughout the whole range of variation.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

In the section Air Engineering, attention is called to the article by Prof. Brabbée and Dr. Bradtke on the graphical process for the determination of dimensions of pipes in ventilating and heating systems, developed on the basis of an extensive series of tests. In the same section is reported the beginning of an article on graphical tables for calculating reciprocating compressors. Both articles are interesting as showing a strong tendency toward development of graphical methods for solving engineering problems.

The article by Binder on initial temperatures of combustible gases and liquids is an interesting contribution towards a question of considerable interest to the designers of gas and explosion engines (though it is quite possible that the data indicated therein have been already disconnted empirically).

In the section Mechanics, is reported an article on recent tests of the effective forces between driving belt and pulley. Among other things, these tests have shown the fallacy of the idea that the belt delivers a higher frictional resistance in gliding on a rough pulley than on a smooth one.

In the same section is continued from the August Journal the abstract on theory of resistance to rolling of a hard body over a plastic surface.

From a German paper is abstracted an account of experience with coke firing under boilers, indicating some limitations of this kind of fuel, and giving suggestions as to the best methods and most suitable type of equipment.

A discussion of the location of the neutral zone in heated buildings is presented from a paper before the American Society of Heating and Ventilating Engineers.

F. L. Fairbanks before the American Society of Refrigerating Engineers describes the design and installation of a large ammonia compression machine, giving in detail the system adopted for ordering the machinery and its installation. The suction valve of the refrigerating machine is described and illustrated, and some indicator diagrams are given from the ammonia end of the compressor.

The fundamental problems of engine design and formulae for comparison of gasoline and automobile performances are reported from two papers presented before the Society of Automobile Engineers.

From the Journal of the South African Institution of Engineers is taken an abstract of a paper on the influence moisture in air has on mine ventilation. Among other things, the author considers the physiological effect of excessive moisture and gives some rules as to the basic methods of designing mine ventilation systems.

## FOREIGN REVIEW

### Air Engineering

Simplified Graphical or Analytical Process for the Determination of Dimensions of Pipes in Ventilating and Heating Installations, Professor Brabbée and Dr. Bradtke.

Abstract of No. 21 of *Communications of the Testing Laboratory for Heating and Ventilation,* of the Royal Technical High School, Berlin (the original communication is not available in the Library of the Engineering Societies). It is devoted to the calculation of high pressure and steam heating and ventilating installations by a method previously established for the determination of the diameters of piping in hot water heating systems.

The following notation is used:

$H$ = Total pressure in kg/m²
$R$ = Frictional resistance per meter of piping in kg/m²
$Z$ = Fall of pressure due to single resistances in kg/m²
$L$ = Volume of air in m³/sec.
$f$ = Cross section of the passage in m²
$l$ = Length of passage in meters
$v$ = Velocity of air in m/sec.
$d$ = Diameter of passage in millimeters
$g$ = Acceleration due to gravity in m/sec.²
$\gamma$ = Specific weight of air in kg/m³
$a$ = A constant
$\xi$ = Resistance coefficient.

In the equation

$$H \geq \sum_{1}^{n} (lR + Z) \quad [1]$$

all frictional resistance of the air may be expressed by a potential function having the following form:

$$R = \frac{av^n}{d^m} \quad [2]$$

The single resistances are taken care of by the following equation:

$$Z = \xi \frac{v^2}{2g} \cdot \gamma \quad [3]$$

In connection with these three equations, the following is added:

$$L = fv \quad [4]$$

Equation [2] has been derived from the data of a considerable number of investigations reported in technical literature on frictional resistance of air in metal passages. It is based on 293 observations made on passages having a diameter from 19 to 1000 mm., and since $a$ remains constant only for a definite specific weight of air, the corresponding specific weight $\gamma$ had to be brought in accordance with the conditions existing in the ventilating passages. This was done by means of data on the influence of $\gamma$ on the air resistance derived from the very careful investigations of Fritsche. Further were used data obtained experimentally by Rietschel on the flow of air in rectangular sheet iron passages. There were no modern investigations covering the case of brick passages, but it was found that the values obtained from equation [2], when doubled, were in nearly perfect accordance with the values given for brick passages in Rietschel's *Handbook for the Calculation and Design of Ventilating and Heating Plants* (in German). Therefore, the final formula in which the average roughness of the ventilating passages is taken care of by varying the velocity exponent $n$ can be applied both for the round and rectangular sheet iron and brick passages.

Among other things, the investigation gives a table indicating the values which have to be used in the above equa-

tions. There are four more tables covering the following subjects: 1, equivalent diameters and cross-sections of passages for rectangular passages from 0.1 to 2.5 m. length of side; 2, effective pressures in passages 1 m. high, prevailing at various external and internal temperatures; 3, single resistances generally occurring in practice; 4, calibration constants for frictional resistances at $\gamma$ equals 1.2 and temperatures in the passage varying from 0 to 80 deg. The new method of calculation is illustrated by three examples. (*Vereinfachtes zeichnerisches oder rechnerisches Verfahren zur Bestimmung der Rohrleitungen von Lüftungs-und Luftheizungsanlagen,* Professor Dr. Brabbée and Dr. Bradtke, *Gesundheits-Ingenieur,* vol. 38, no. 28, p. 325, July 10, 1915, 2 pp., *p.*)

### Graphical Tables for Calculating Reciprocating Compressors, Immerschitt

M. Hirsch ("Air Pumps, the Design, Calculation and Testing of Compressors and Vacuum Pumps," in German) was the first to offer a complete method for graphical calculation of reciprocating compressors. His method, however, did not take into consideration losses in the suction opening of the pressure valves and expulsion of the compressed air from the cylinder. The reexpansion of the air from the clearance space is also taken into account.

When such diagrams are plotted, certain relations have to be taken into consideration. First, compressors equipped with automatic valves are here considered primarily. Further, assumptions have to be made as to the character of the air (whether dry or moist), as to the cooling exponent of the compression and re-expansion line, and as to the dimensions of the clearance of the compressor. In plotting the suction and expulsion lines the speed of the compressor has to be also considered. Hence the diagram does not apply to any kind of compressors, but only to those equipped with automatic valves and jacket cooling, and not to slide valve compressors, compressors with the equalitation of pressure, semi-wet and wet compressors. This does not, however, matter much because semi-wet and wet are scarcely built any more, and compressors with automatic valves and jacket cooling are mostly used.

As regards the selection of data of design the clearance space was taken to be 2.5 per cent. Fig. A shows the air diagram for 7 atmospheres absolute air compression com-

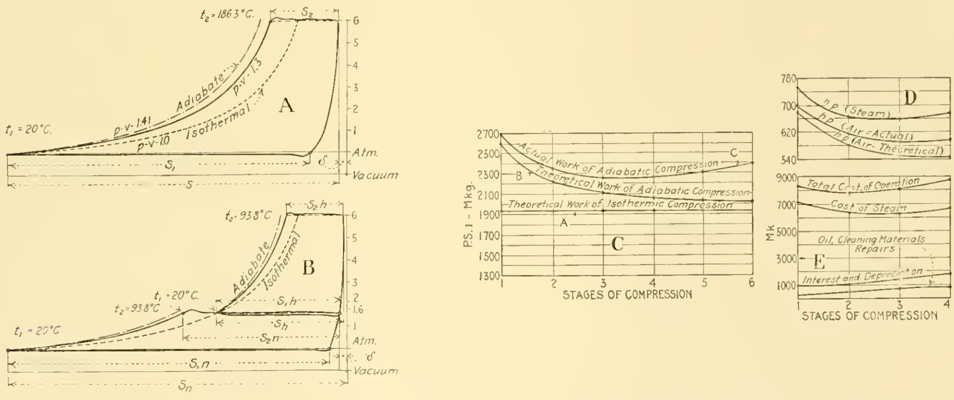


FIG. 1 DIAGRAMS SHOWING COMPARATIVE PERFORMANCES OF SINGLE AND MULTISTAGE COMPRESSORS

of air and in its displacement from the cylinder due to the motions of the valves and valve resistances. As a result, in order that the data graphically obtained by the Hirsch method might be used, they had to be multiplied by certain coefficients obtained experimentally.

The present author attempts to offer a graphical method for handling reciprocating compressor problems based on somewhat different principles. In order to obtain tabular values for the single stage and two stage compression and for different end pressures, compressor diagrams were plotted in shape very near those found in actual practice. Fig. 1A shows a diagram for single stage compression and 6 atmospheres gage pressure; and Fig. B a diagram for a two-space compression with the same end compression. In these diagrams plotted from data found in numerous diagrams taken in actual practice, all the resistances met with in the operation of a compressor with automatic suction and pressure valves, are found to be taken into account, such as losses in opening of the suction valve, taking in of the air, in compression because of the heating of the air, pressors. In construction of the compression and re-expansion lines the exponent 1.3 was adopted which pre-supposes an effective cooling, without, however, making serious demands on it. The suction pressure is taken to be 5 per cent. below the outside air pressure, while the compression pressure (the use of light automatic valves being assumed) is 0.15 atmospheres higher than in the compression chamber. Multi-stage compression results in lower power consumption of the compressor for the same air output, greater volumetric efficiency, better maintenance of the compressor and drier compressed air. As shown in Figs. C, D and E the most favorable from a technical point degree of compression is attained on the assumption of 7 kg. per sq. cm. end compression, in three stages. In four-stage compression the losses through friction in suction and additional compression in the fourth stage are greater than the gain obtained through the triple return cooling as compared with the double one. If in addition the increased work in piston friction in three stage compression is taken into consideration as well as the additional cost of the second intermediary

cooler, and the higher consumption of cooling water, it is found that the most desirable reciprocating compressor for compression from 6 to 7 atmospheres is the two-stage one.

Hence the tables worked out apply for single stage compression to air pressures of 3-8 atmospheres absolute, and for two-stage compression from 5-20 atmospheres absolute; while the three-stage compression has been left entirely out. Fig. D gives an air diagram for two-stage compression at 7 kg. absolute air pressure.

The diagrams have been plotted in such a way that the work done in low pressure and high pressure cylinders and the end temperatures be equal to one another. Hence the compression ratios in both of them must be equal or both must be equal to the square root of the absolute end compressor. (*Graphische Tabellen zur Berechnung von Kolbenkompressoren,* Immerschitt, *Der praktische Maschinen-Konstrukteur,* vol. 48, nos. 27/28, July 15, 1915, article not finished; abstract will be continued in an early issue.)

### Internal-Combustion Engineering

Initial Temperatures of Combustible Gases and Liquids

For the proper operation of gas, benzole and gasoline engines, the explosion temperatures generated by the combustion of the fuels are of great importance. There is scarcely any doubt that the temperatures as previously computed on the assumption of the specific heats being constant were too low. Therefore the author has recomputed these temperatures, using increasing specific heats, and the difference in results, as shown by Table 1, are quite large.

In accordance with the more modern data on specific heats increasing with temperature, it is found, for example, that the specific heat of 1 cbm of carbon dioxide at 1000 deg. cent. is as follows:

$$1000(0.4886 + 0.00024 \times 1000)$$

Hence the increase of temperature for 1 deg. cent. is equal to $0.4886 + 0.00024 \times t$.

And from this is computed the general formula for the combustion and explosion temperatures:

$$T = \frac{WE}{cbmCO_2(0.4886 + 0.00024t) + cbmH_2O(0.4692 + 0.00015t)}$$

$$\frac{WE}{cbmN(0.308 + 0.00007t)}$$

The initial temperatures have been computed with theoretical air volumes and on the basis of combustion with pure oxygen; for explosives such mixtures may perhaps find their application. The temperatures when taken with pure oxygen are at rising temperatures.

In the table the volumes of the explosive mixtures are given before and after combustion, and from this are computed the gage pressures available during explosion. Of considerable interest are the usually small differences in the initial temperatures, which fact the author explains by assuming that what occurs is the conversion of oxygen into carbon dioxide and water vapor. Since, however, the difference in heating value of these two elements in equal contact with oxygen is not particularly great, the initial temperatures also cannot vary very much. The extremely powerful noise occurring during explosion of acetylene is, therefore, due less to the development of a high pressure than to some sort of acoustic action.

Sooner or later these much lower initial or explosive temperatures will have to be taken into consideration in designing gas and explosion engines, unless practice has already discounted these temperatures empirically. (*Ueber Anfangstemperaturen von brennbaren Gasen und Flüssigkeiten,* O. Binder, *Oel- und Gasmaschine,* vol. 15, no. 4, p. 25, July 1915, 2 pp., *et.*)

### Mechanics

Recent Tests on the Effective Force between Driving Belt and Pulley

The law of friction of solid bodies applies fully only to the case of surfaces of belts and pulleys clean and absolutely free of grease and the nearest approximation is the case of new belts having very little grease on them. If on the other hand there clings, more or less perfectly, on the smooth surfaces of the belt and pulleys a thin skin of liquid, then, in accordance with the amount of its adhesion, the magnitude of the effective force varies as the internal friction of the liquid and thus becomes functionally dependent on all other variables, in particular: the effective surface, the gliding velocity, and the temperature and viscosity of the adhering liquid. Under such conditions new forces come into operation, in some cases many times greater than those acting in the case of pure friction between solid bodies. The properties of the belt material become of secondary importance, while the properties and amount of belt grease assume a preeminent importance.

The presence of a uniformly thin and smooth skin of grease on the gliding surface of a belt has a double effect. In the first place, it makes possible the rise of large forces between belt and pulley, especially with increase in gliding velocity. Second, it protects the surface of the belt. In particular for high belt velocities belts should be as flexible, soft and well greased as possible. In the case of a slightly greased belt, the application of a proper belt grease to the clean surface can help in building up a thin skin of grease between the belt and the smooth pulley which raises the effective forces as has been proved by experiments.

When there is a skin of liquid present, the magnitude of the effective forces increases, in the first place, with the gliding velocity. This makes the belt drive stable as regards overloads (up to certain definite limits of this latter); when large peripheral forces have to be transferred, higher gliding velocities must be used, and they lead to increased frictional resistances on the assumption that the temperature remains permanently constant. The average gliding velocity of the belt and pulley increases (all other conditions being the same and peripheral forces transferred being equal) approximately in proportion to the belt speed. In the high speed belts, therefore, usually larger frictional forces are in operation.

The superiority of large pulley diameters and comparatively wide belts, established by experiments, is partly explained by the functional dependence existing, in the case of well greased belts, between the magnitude of the effective forces and that of the gliding surfaces.

With rough surfaces of pulleys the effective force is greater than with the smooth pulleys only when the velocity of gliding is negligibly small. Otherwise it is always smaller, the more so the more perfectly the face of the belt is covered by a thin skin of fluid. As a result rough pulleys not only cut down the life of the belt through increased

wear but do not accomplish the purpose of increasing the frictional resistance in gliding. (*Versuche über die Grösse der wirksamen Kraft zwischen Triebriemen uns Scheibe,* A. Friedrich. *Zeits. des Vereines deutscher Ingenieure,* vol. 59, nos. 27, 29 and 30, pp. 537, 580 and 608, July 3, 17 and 24, 16 pp., 39 figs. *etA.*)

THEORY OF RESISTANCE TO ROLLING OF A HARD BODY OVER A PLASTIC SURFACE. B. B. Schultz

A treatment of the resistance to rolling of cylindrical wheels over various types of ground, considering in particular resistance to rolling of driven wheels. The present article, while an independent unit, is, to a certain extent, a further development of an article previously published by the author and abstracted in *The Journal* August 1915, p. 478.

As regards the resistance to rolling of driven wheels, the author gives in a table the various coefficients (determined experimentally) of resistance of motion of ordinary wagons over horizontal roads of various kinds, compiled from data found by Morin, Résal and Watson. None of these investigations indicates how the resistance to motion varies with the change of diameter of the driven wheels, the width of their rims and presence or absence of gripping protuberances, and what are the most favorable dimensions of a wheel giving minimum resistance to rolling. In order to answer these questions, the author breaks up the complex phenomenon of rolling into its simplest components, by considering three of its elements: viz. *first,* resistance to motion due to friction in the journals of the wheels of the wagon; *second,* due to vibrations of the body of the wagon, and *third,* resistance of ground to rolling of the rims of the wheels.

The resistance due to friction in the journals of the wheels of the wagon may be considered as a braking force $R_o$ kg applied horizontally to the axis of the wheel, and, mechanically, may be expressed by the following formula,—

$$R_o = \mu \frac{d}{D} . Q$$

where $d$ is the diameter of the journal of the shaft, $D$ the diameter of the driven wheel, $Q$ the load on the shaft in kilograms and $\mu$ coefficient of friction on the surface of the journal. According to M. Forestier, this coefficient is 0.1 for ordinary journals lubricated with journal grease, 0.01 for patent bearings lubricated with oil, and 0.005 to 0.0025 for lubricated ball-bearings. According to the investigation made by the author, the diameter $d$ of the journal does not exceed, in the case of heavy trucks, 60-80-100 mm, and for light wagons 40-50 mm, so that the ratio $\frac{d}{D}$ does not usually reach 0.110 and does not fall below $\frac{1}{30}$, being on the average approximately $\frac{1}{20}$. On the whole, the author shows that resistance to the motion of the wheel, due to friction in the shaft, does not exceed usually one-half of one per cent. of the load of the shaft and in the least favorable case, does not reach one per cent. of that load.

The resistance to motion due to vibration of the wagon is considered as the entire increase of resistance to motion due to the velocity of motion. The author comes to the following conclusions as to this particular item in the resistance to motion: The variation of the resistance to motion of a wagon with the increase of its velocity is observed only when motion occurs over uneven hard ground where this resistance is great, and in the the first approximation, the resistance increases with the velocity, in a straight line. Resistance to motion due to the vibration of the wagons in the case of motion over uneven, hard ground, at very low velocities, amounts to not more than some tenths of one per cent of the load of the wagon. In rolling over smooth ground, the resistance to rolling of hard tires may be considered as practically independent of the velocity. The resistance to the motion of the wagon over soft ground (subject to deformation), is on the average greater than the resistance to motion over every other kind (hard) of ground, and reaches the maximum absolute value (up to 25 per cent) of the load on the wheels. The resistance to rolling of wheels over soft ground (subject to deformation), is the main constituent of resistance to motion.

The state of theory as regards resistance to rolling is rather unsettled. According to the law of friction in motion formulated first by Coulomb and accepted by Morin, this resistance is proportional to load and inversely proportional to the diameter of the rolling cylinder; according to Professor Hele-Shaw, it is inversely proportional to the square root of the diameter; and according to conclusions drawn from the present investigation, it is inversely proportional to the diameter raised to the power 2/3. Further, the coefficient of resistance to rolling is, according to Coulomb and Morin, independent of the load, while according to tests

TABLE 1. INITIAL TEMPERATURES OF EXPLOSION OF COMBUSTIBLE GASES AND LIQUIDS

| | Initial Volume | Final Volume | Initial Volume | Final Volume | INITIAL TEMPERATURES | | | | PRESSURES | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | at constant specific heat | | with varying (upwards) specific heat | | | |
| | with oxygen | | with theoretical amount of air | | with oxygen | with theoretical amt. of air | with oxygen | with theoretical amt. of air | with oxygen | with theoretical amt. of air |
| | C. B. M. | C. B. M. | C. B. M. | C. B. M. | °C | °C | °C | °C | Atmospheres | |
| Hydrogen | 3,00 | 22,93 | 6,771 | 42,01 | 6781 | 2756 | 2851 | 1711 | 7,63 | 6,205 |
| Carbon Monoxide | 3,00 | 21,775 | 6,771 | 43,361 | 7067 | 3042 | 2694 | 1775 | 7,26 | 6,53 |
| Methane | 3,00 | 34,15 | 10,542 | 71,78 | 7160 | 2440 | 2829 | 1583 | 11,38 | 6,86 |
| Acetylene | 7,00 | 85,49 | 25,855 | 203,06 | .... | .... | 3610 | 1953 | 12,21 | 7,85 |
| Ethylene | 4,00 | 51,34 | 15,313 | 114,093 | 8620 | 2750 | 3226 | 1758 | 12,84 | 7,45 |
| Benzole | 17,00 | 231,65 | 73,565 | 544,47 | .... | 2790 | 3234 | 1717 | 13,63 | 7,40 |
| Gasoline | 12,00 | 183,90 | 53,481 | 400,78 | .. | .... | 3068 | 1661 | 15,33 | 7,50 |
| Alcohol | 4,00 | 55,06 | 15,313 | 110,063 | .... | .... | 2728 | 1566 | 13,77 | 7,19 |
| Illuminating Gas | 2,135 | 22,95 | 6,435 | 45,51 | 7500 | 2530 | 3126 | 1747 | 10,75 | 7,07 |

made by the committee of the British Association, it decreases with the load. According to tests at the automobile laboratory of Professor Riedler, it increases with the load, and according to the data of the present investigation, it increases with the load slightly and is proportional to the cube root of the load.

The present investigation is limited to the consideration of resistance to rolling of driven wheels moving over a horizontal and plastic roadway. The specific resistance of the ground to crushing is assumed to be proportional to depth $y$ of crushing, so that $f = f_1.y$, where $f_1$ in kg per cbm is the coefficient of specific resistance of the ground to crushing.

If we denote by $Q$ kg the load on the surface of rolling, by $R$ kg the effort of rolling applied to the axis and forcing the wheel to roll uniformly, by $B$ cm the width of the rim and by $y_0$ cm the depth of the impression left in the ground by be in equilibrium, and therefore the algebraic sum of their vertical projections must be equal to zero: $\Sigma Y = 0$ or

$$Q - SdF.\cos.\alpha = 0$$

where $SdF.\cos\alpha$ must be spread over the entire surface $S$ of rolling in contact with the ground. But $dF.\cos\alpha = B.f.d\alpha$, since $dF.\cos\alpha = (F.ds)\cos\alpha = FBdl'.\cos\alpha$; on the other hand, as one can see from Fig. 2 B, $dl'.\cos\alpha = dx$, and hence

$$dF.\cos\alpha = F.B.dl'.\cos\alpha = F_1.y.B.dx \ldots\ldots [2]$$

which brings the equation to the form:

$$Q = F_1.B.\int_0^{y_0} y dx \quad \ldots\ldots [3]$$

The properties of the circle indicate the following (Fig. 2 C):

$$x^2 = [D - (y_0 - y)](y_0 - y) \ldots\ldots [4]$$

If we differentiate this equation, free it from $x$ and substitute in equation [3], we have then:

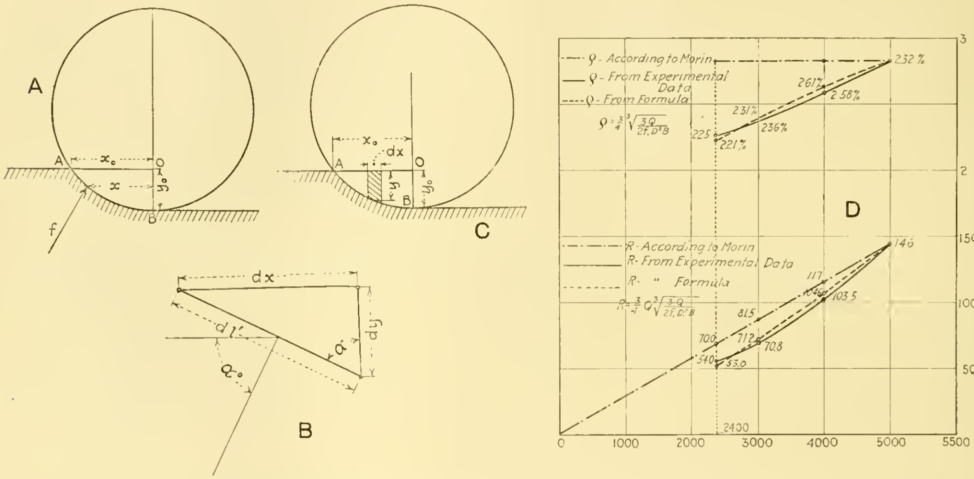


FIG. 2 THEORETICAL CURVES OF RESISTANCE TO ROLLING AS COMPARED WITH THOSE OBTAINED EXPERIMENTALLY

the rolling cylinder, then the specific work $L_0$ in kg per cm required to deform 1 sq. cm of the surface of the ground to a depth $y_0$, will be in kg-cm

$$L_0 = \int_0^{y_0} f.dy = \int_0^{y_0} f_1.ydy = f_1\frac{y_0^2}{2}$$

and hence the work per unit of length of roadway (1 cm) or the magnitude of the resistance to rolling will be

$$R = \frac{L}{l} = L_0.B \ldots\ldots [1]$$

Now (Fig. 2 A) let the origin of coordinates be at $O$; the axis of $X$ along the line $OA$; the axis of $Y$ along the line $OB$ and the axis of $Z$ normally to the plane of the drawing. If we take an element $dS = B.dl'$ on the surface of the rolling cylinder, which $dl'$ is the element $MN$ of the arc $AB$; let $dF = f.dS$ be an element of the force of pressure of the ground against the surface of rolling corresponding to $dS$; assume $f$ the specific pressure on the ground to be proportional to the depth of crushing $y : f = f_1$. If we neglect friction, we by that very fact assume that $dF \perp dS$. External forces applied to a uniformly rolling body, must

$$Q = F_1.B\int_0^{y_0} y \frac{D - 2(y_0 - y)}{2\sqrt{[D - (y_0 - y)](y_0 - y)}} \ldots [5]$$

where the fact has been already taken care of that, in differentiation, the signs of $ydx$ and $dy$ are opposite.

It is theoretically possible to solve the complicated integral in equation [5], but practically there would not be much use in doing so. By approximate substitution, the author derives the following two expressions (the numbers of the equations are those in the original article):

$$Q = \frac{2}{3}.F_1.B.\sqrt{D}.y_0^{3/2} \ldots\ldots [7]$$

$$\rho = \frac{3}{4}\sqrt[3]{\frac{3Q}{2F_1.D^2.B}} \ldots\ldots [12]$$

where $\rho = \frac{R}{Q}$, and is the coefficient of resistance to rolling.

Formulae [1], [7] and [12] give the solution of the problem of resistance to rolling in the case of a cylindrical wheel with a hard rim, moving over a plastic roadway, on the assumption that the resistance of the ground is proportional to the

depth of its deformation. The author shows that the expression for $R$ obtained in equation [1] by means of computing the work of deformation of the ground, may also be obtained from the equations stating the conditions of equilibrium of a rolling wheel, by equating to zero the algebraic sum of the horizontal projections of all forces acting externally on the wheel. From this, he derives the following equations, which give a general and analytical solution of the problem of resistance to rolling of a driven wheel with a hard cylindrical rim, moving along a plastic roadway, this solution being independent of the law of resistance of the ground to deformation:

$$R = B\int_0^{y_0} F.dy \quad\ldots\ldots [13]$$

$$Q = B\int_0^{x_0} F.dx \quad\ldots\ldots [14]$$

Theoretically, therefore, the problem can always be solved, no matter what it is, by the experimental law of resistance of the ground to the deformation. Equations [13] and [14] can be integrated with particular ease in the case when $f$ = constant = $f_0$; i.e., when the specific resistance of the ground to deformation is constant, in which case

$$R = F_1.B.y_0 = \frac{Q^2}{F_0.B.D} \quad\ldots\ldots [15]$$

$$\rho = \sqrt{\frac{y_0}{D}} = \frac{Q}{F_0.B.D} \quad\ldots\ldots [16]$$

$$Q = F_0.B.\sqrt{D.y_0} \quad\ldots\ldots [17]$$

$$y_0 = \frac{Q^2}{F_0^2.B^2.D} \quad\ldots\ldots [18]$$

It is, however, important to bear in mind that, as shown by the author, the law of resistance assumed above has been shown, by the experiments of the author, not to be in accordance with actual conditions. From this, the author proceeds to show the magnitude of error caused by the use of the simplified expression for $x^2$ in equation [4].

There is no way of easily verifying the correctness of the formulae derived by the author, although theoretically a single typical test, properly carried out, would have been sufficient for this. The equation for $\rho = \frac{3}{4}\sqrt{\frac{y_0}{D}}$ derived on the assumption of the resistance of the ground and the depth of its deformation being proportional to one another, foretells the magnitude of the coefficient $\rho$, which is, on the other hand, equal to the ratio of experimental magnitudes, $R/Q$. If, now, we write in a general form

$$\rho = \xi\sqrt{\frac{y_0}{D}}$$

we can show by means of the initial equations that $\xi$ depends on the law of resistance of the ground to deformation and, in particular, if the resistance is constant (independent of depth), then

$$\xi = 1, \text{ and } \rho = \sqrt{\frac{y_0}{D_1}}$$

From this is obtained a remarkable conclusion, viz., that if the coefficient $\xi$ be determined by means of data obtained experimentally from the equation

$$\frac{R}{Q} = \xi\sqrt{\frac{y_0}{D}} \quad\ldots\ldots [19]$$

it is possible from its magnitude to judge of the nature of the law of deformation of the ground in the expectation that the smaller $\xi$ is as compared with unity, the more rapidly will the resistance of the ground increase with the depth of deformation.

From equation [1] for $R$, it follows that the absolute magnitude of the resistance to rolling of a cylindrical wheel over a given ground is proportional to the width of the rolling rim $B$ and the square of depth $y_0$ of the imprint of rolling, provided the resistance of the ground is proportional to the depth of deformation. From another equation, it follows that if the resistance of the ground is proportional to the depth of deformation, the specific resistance to rolling of the wheel $\rho = \frac{R}{Q}$ is deteremined entirely by the specific magnitude of the penetration of the wheel into the ground $\frac{y_0}{D}$. From the same formula, it follows that a relatively deep penetration of the wheel into the ground is a necessary and sufficient index of a large relative resistance to rolling. From equation [12], it follows that for a given wheel and roadway the relative resistance to rolling is not a constant magnitude but one slightly increasing with the load (proportional to $Q^{\frac{1}{3}}$) if the resistance of the ground is proportional to the depth of its deformation. It may be noticed in this connection that experiments in the laboratory of Professor Riedler have shown the practical independence of resistance to rolling of a truck, from the velocity of rolling over a given ground, and also the increase of the relative resistance to motion with the load.

Diagram 2 D gives a comparison of theoretical curves of resistance to rolling with curves obtained experimentally, at the Riedler laboratory, on tests with a truck equipped with iron tires and rolling over wooden boards. This diagram shows, *first,* that the independence of the relative resistance to rolling assumed by Coulomb and Morin in their general law of resistance to rolling, is not true in this particular case since it disagrees with the experimental data to the extent of about 30 per cent; *second,* likewise in the given case is not correct the assumption that the specific resistance of the ground to deformation is constant, since it disagrees with the experimental data to the extent of about 40 per cent. The formula of resistance to rolling of a hard cylinder over a plastic roadway derived above on the assumption of the resistance of the ground being proportional to the depth of deformation satisfied in a manner sufficient for practical purposes the qualitative data obtained from experiments.

Equation [12] shows also that the magnitude of the relative resistance to rolling of a hard wheel over a given plastic roadway increases (slowly) with the load per unit of width of the rim of the wheel, in proportion to $\frac{Q^{\frac{1}{3}}}{B}$ and decreases more rapidly with increase of the diameter of the wheel (inversely proportional to $D^{\frac{2}{3}}$). A 3 per cent increase of the diameter of the wheel decreases the resistance to rolling by 2 per cent, while an increase of the width of the rim of the wheel by 3 per cent decreases the resistance to rolling by 1 per cent, so that in order to reduce the resistance to rolling, it is advisable to use wheels of larger diameter even though of smaller width. The depth of deformation of the ground decreases slowly with the increase in the diameter of the driven wheels, and more rapidly with the reduction of load from unity of weight on the rim of the wheel; hence, in the interest of the preservation of roads, wide wheels, even though of small diameter, should be used. The author

recommends, therefore, in the interest of road preservation, that the load per unit of width of rim should be regulated by legislation, in accordance with the formula which he likewise suggests.

### Railway Engineering

#### Equalization of Masses in Motor Driven Locomotives and Oscillations Due to It, H. Henich

Discussion of the problem of equalization of masses, or rather, lack of equalization and oscillations due to it on motor driven locomotives. Because of lack of space only a very brief abstract of this interesting article can here be given.

In motor driven locomotives the driving plant consists usually of a horizontal slow-speed single cylinder engine; the reciprocating parts of a driving engine create centrifugal forces directed horizontally while the engine is running. They, in their turn, create forces directed vertically and varying with time as a function of their magnitude, in addition to which the centrifugal forces of the second order are free to act.

Because a locomotive is located elastically on its underframe, there arise inside the locomotive, on account of the action of the vertical forces, oscillations which are limited only to motions up and down if the driving engine is located so that its axis is in the plane of the centre of gravity of the locomotive. These oscillations in their turn create not inconsiderable additional forces which strain the axes and springs of the locomotives, and put an additional load on the roadway.

The author develops the formulæ for the calculation of oscillatory displacements, and of the additional forces acting therein. It is further shown that there is a "critical ratio" between the speed of the rotation of the engine and weight of the locomotive, and the constant of the spring, at which the amplitude of oscillation and the additional forces corresponding to it are theoretically "infinite" and practically "very large." Next it is shown what is the influence of a change in the locomotive springs or the speed of rotation of the engine on the magnitude of the amplitude of oscillations or the additional forces.

The author discusses also the movements due to centrifugal forces of the second order and shows what may be expected in the growth of the oscillatory phenomena if the driving engine be located not in the plane of the centre of gravity of the locomotive; but if, instead, multi-cylinder horizontal engines be used as a driving plant. In conclusion it is shown what type of engines are best to be used in larger sizes of locomotives, whenever a quiet running of the locomotive is considered of really serious importance. (*Zur Frage des Massenausgleiches und der dadurch enstehenden Schwingungen bei Motorlokomotiven*, H. Henich, *Der Oelmotor,* vol. 4, nos. 1 and 3, pp. 3 and 102, April and June 1915, 10 pp., 5 figs. *dt.*)

### Steam Engineering

#### Coke as a Fuel Under Boilers, G. Wirthwein

Discussion of the utilization of various kinds of coke as boiler fuel. Both blast furnace and gas cokes are considered.

The average analysis of blast furnace coke is given as follows:

| | Per Cent. |
|---|---|
| Moisture | 8.88 |
| Ash | 9.81 |
| Carbon | 78.02 |
| Hydrogen | 0.54 |
| Sulphur | 1.03 |
| Oxygen | 0.86 |
| Nitrogen | 0.86 |
| | 100.00 |

The moisture content of coke varies in accordance with its origin. This variation is sometimes ascribed to moisture taken in by the coke during transportation, but experiments by Dr. Thaler show that this may be so only to a limited extent. Table 2 shows the amount of moisture absorbed by coke after lying submerged in water for corresponding periods varying from one to twenty-eight hours. From these tests it appears that while sample No. 1 has absorbed 10.2 per cent. increase in the other samples was as low as 2.2 per cent. (No. 4) which was probably due to the fact that sample No. 1 was very porous and sample 4 very hard. Dr. Thaler concludes from his tests that in transportation of porous coke even during strong rains, increase of moisture content will not exceed 4 per cent., and with hard coke from 1 to 2 per cent.

TABLE 2 ABSORPTION OF MOISTURE BY COKE KEPT UNDER WATER (WATER CONTENTS IN PER CENT)

| No. of Sample | Original Water Content | Moisture absorbed after coke has been kept under water for Hours: | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 3 | 6 | 24 | 28 |
| 1 | 8 | 18.2 | 17 | 17 | 15.7 | 14.4 |
| 2 | 8.5 | 14.5 | 13.3 | 13.3 | 13.3 | 13.3 |
| 3 | 6.7 | 11.2 | 11.2 | .... | 10.1 | 8.9 |
| 4 | 10.4 | 12.6 | 12.6 | .... | 11.5 | 11.5 |

The experience of German factories and electric plants with coke firing since the beginning of the war was approximately as follows: It was found that coke alone could not be burned at all on traveling or chain grates. That might have been expected. When coal is burned on this type of grate the ignition of the gases brings the arch to a very high temperature, and as a result coals even very rich in gases can be burned on such grates practically without generation of any smoke. On the other hand, when coke is burned there is no flame at all and as a result the arch remains at a lower temperature. Hence when the coke is moved forward on the grate, it does not find a zone of incandescence, which leads to the fire simply going out. On the other hand, a mixture of three-fourths coal and one-fourth coke can be burned quite successfully on such grates.

The experiments with burning coke on the ordinary flat grate proved far more encouraging as it was found that even pure coke could be burned when the conditions of draft were favorable. This was especially easy to attain with artificial draft such as is produced by a fan or steam jet blower; for example on locomotives even pure coke could be easily burned in large lumps, presumably on ac-

count of the sharp draft there available. In the district of the Bergisch Steam Inspection Association several important concerns have adopted hand firing on flat grates, using a mixture of two parts of coal to one part of coke and without encountering any serious difficulties.

When the coal-coke mixture is fired on the horizontal grate, the fireman must look out for certain particulars. The furnace must be fired up with pure coal of as good a quality as is available; the coal-coke mixture is not used until after the fire has burned up well and is of sufficiently high temperature; and the fuel bed has to be kept somewhat higher than with coal. For a time before cleaning the clinker it is advisable to use unmixed material, that is pure coal, so that the fire shall burn away uniformly, as only in this way are the complaints prevented that unconsumed coke is taken out from the fuel bed with the clinker.

On the whole it was found that the gas coke is a more suitable material for boiler furnaces than blast furnace coke. Large sized coke can be burned on flat grates with hand firing only when a strong draft and a good grate cooling are available, as for example, in locomotives. For firing small coke and coke breeze not mixed with coal, special grate types with undergrate blowers are required. This type of coke can be burned on ordinary flat grates only when mixed with an easily baking coal. In general, it appears however that there is quite a wide field in steam boiler firing where coke can be usefully employed without large and expensive alterations in furnace design being required. (*Koks und seine Verwendung für Dampfkesselfeuerung*, G. Wirthwein. *Zeits für Dampfkessel und Maschinenbetrieb*, vol. 38, no. 29, p. 241, July 16, 1915, 3 pp., 1 fig. *egp.*)

### Miscellanea

#### Recent Tests on Flow of Water Acted on by a Propeller

Description of tests made in the small experimental basin of the Royal Technical High School in Berlin. The outbreak of the war has caused a discontinuance of the tests, but some of the tests have been found to be sufficiently advanced to make it advisable to publish their results. Pitot tubes were used as measuring instruments throughout.

The article describes the experimental arrangements and methods of carrying out the tests and reports in a general manner the results obtained, given in more detail in the form of numerous curves. One of the interesting phenomena observed is the fact that behind the propeller in the region of the hub a very powerful flow of water *towards* the propeller was found. Continual variations of the water column as high as 170-180 mm have been observed. In the region of the periphery of the hub turbulent motions were found and only near the vanes was the water found to flow backwards. This was the water which was sucked in by the propeller, accelerated in it, thrown back by its motion, and in this way made effective for driving the ship forward.

The greatest velocities of water were found at low speeds within a region extending from 0.25 to 0.75 of the radius of the propeller. At higher speeds of rotation the maximum of water velocity shifts more toward the end of the vanes. Thus at 800 r.p.m., it lies at about 0.6 of the radius all around the propeller; from 0.75 of the radius both the pressure and the velocity curves at nearly all speeds investigated fall off constantly and at about 0.82 radius pass through the zero line. But beyond 0.82 of the radius there is again found the flow of water towards the propeller. These various velocities of flow are of different strengths at various distances from the axis of the shaft. Thus, for example, at 0.92 of the radius the water column gave the same indication as at 0.98 of the radius. This indicates the presence of eddies at the edges, occurring in addition to the proper propeller flow. Only at a distance of 1.25 radius is there again found quiet water all along the circumference.

All this data has been obtained by measurement over a cross section located about 20 mm behind the rear edge of the propeller blade. Essentially therefore they apply only to this cross section, but since the shape of the "screw water" is nearly cylindrical, these figures apply approximately also to several other cross sections behind the propeller. Fig. 3 gives a diagramatic view of a possible occurrence of water currents both in front and behind the propeller. Only components in the longitudinal direction are therein represented, so that the values in the direction of maximum flow are not determined and the rotation of the water is not indicated (figure is not drawn to scale).

As regards the flow of water towards the screw in the region of the propeller line, the author believes that it is

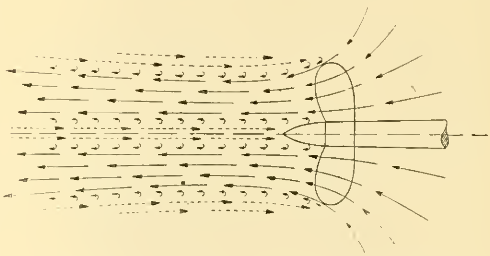

Fig. 3 Image of Flow of Water Displaced by a Propeller

permissible to assume that the partial vacuum behind the hub materially affects the efficiency of the propeller. It appears therefore desirable to make the diameter of the hub as small as possible, that is, as small as the strength of material and the method of fastening the propeller blades make it possible. In front of the propeller, that is, in the water under suction, the stream lines are quite different from those in the water under pressure behind the propeller. In the first place the water column in U-tubes in front of the propeller does not rise as high as in the other case; the flow in the opposite direction in the region of the hub cross-section is entirely missing. The influence of the propeller extends over a very much larger cross section; for example, at 7.5 mm in front of the forward edge of the propeller vane at higher speeds of rotation, quite a noticeable amount of water would be disturbed at 1.5 radii.

The rotation of the water filament has been observed here also, just as in previous tests where such rotation was noticed in sand and air. It differs, however, from the rotation seen behind the propeller through the fact that several cylinders of rotation are formed simultaneously. (*Neuere Untersuchungen und Messungen im Schraubenwasser mittels Düsen*, Professor Flamm, *Schiffbau*, vol. 16, no. 20, p. 553, July 28, 1915, 13 pp., 18 figs. *etA.*)

# ENGINEERING SOCIETIES

## AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

*Vol. 21, no. 2, July 1915, New York City.*



### Can We Locate the Neutral Zone in Heated Buildings? J. J. Blackmore

Discussion of the location of the neutral zone in heated buildings; derivation of formulae for the determination of its location, and discussion and consideration of the effect on the neutral zone of the shape of a building.

A neutral zone is a place or a plane inside a room or

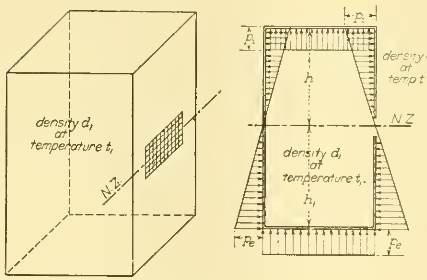


Fig. 4 Neutral Zone in Heated Buildings

building where the pressure is equal to that of the air surrounding it on the outside. Its exact location in the room or building depends upon the relative leakages at the ceiling or upper part of the wall or at the floor or lower part of the walls, and under ordinary conditions in still air, its location will be slightly below the central horizontal plane of the room.

In cold weather, the air contained in a heated building is much lighter than the air surrounding it and therefore has a tendency to rise in accordance with the laws of gravitation. Since it is kept from rising by the walls and roof of the building, a pressure is exerted against the ceiling and upper part of the walls. The distribution of the pressure on the walls and ceiling depends, as the author shows, on the location of the openings connecting the inside of the room with the outside cooler atmosphere. Thus, in Fig. 4, with an opening in the side of the room, the neutral zone will be slightly above the center of the opening, and the following formula will apply:

$Pi = h_1 + h(d - d_1)$ to obtain the pressure by density.

$$Pi = h_1 + h\left(\frac{0.0864 \times 460}{460 + t}\right) \left(\frac{0.0864 \times 460}{460 + t_1}\right)$$

to obtain (the pressure by temperature) where $Pi$ is pressure above the atmospheric; $d$ density of outside air; $d_1$ density of inside air.

The author derives similar formulae for the case of a zone located at a point below the floor line (this condition being produced by the floor register and the ventilating pipe with a strong draft), as well as for a reverse condition with a ventilating pipe from the ceiling. The above formulae apply to the cases of rooms supposed to be airtight and uniformly heated to 70 deg. when the outside air is at zero.

The author discusses briefly how the location of the neutral zone affects the heating conditions and ventilating system of a building. Its location determines the amount of radiation necessary in the various parts of the building to maintain the uniform temperature on the inside, as well as the ventilating pressures in the building. (11 pp., 15 figs., *gt.*)

## AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

*Journal, vol. 2, no. 1, July 1915, New York City*



### Design, Construction and Operation of a 1000-ton Ammonia Compression Refrigerating Machine, F. L. Fairbanks

Description of the design and installation of a large ammonia compression refrigerating machine, of particular interest because it describes in detail the system adopted for ordering the machinery and for its installation.

The Quincy Market Cold Storage and Warehouse Company of Boston, Mass., had, some time ago, to install a large new unit on a very limited floor space, and the installation had to be made in a short time and under very rigid specifications. No builder could be found in a position to handle the work in the specified time and according to the required standard, and it was decided to design and erect a machine with the company's own men contracting for the individual parts with several of the largest machine, foundry and forge shops.

The contracts were based upon a price per pound for each detailed machine part as per drawing and upon the estimated weights of the designer, and paid on the basis of actual weights of castings as delivered to shop to be machined; on difficult machine work, the prices remained fixed regardless of weight. The company furnished drawings, patterns, foundations, cranes, rigging and men for the erection. The drawings carried the specifications for each different material and, where necessary, the physical and chemical characteristics. All important measurements, standing and running fits, and clearances for expansion as well as running clearances, were shown on the drawings in thousandths of an inch, thus making it possible to have multiple parts machined by different men and in separate shops without reference to each other, and at the same time have them fit together accurately when assembled, as proved to be the case.

The designer was to check, test, and accept or reject each individual piece. The patterns were checked before and after molding. The molds were checked after the cores were in and before closing, and the castings were carefully exam-

ined to detect defects before they were machined, all with a view to finding and rectifying errors before they had developed in time and money. This proved an efficient method as there was no part of the machine rejected for defect either in material or workmanship after its arrival at the power plant for erection. The immense pieces to be installed were handled by the company's own men, partly because of the fact that practically all the material had to be carried on cranes over running engines; although the rigging was carefully tested, when parts were passing over some of the larger compressors, a man was stationed at every important steam and ammonia valve with orders to shut it off if he heard a carsh: everything went on, however, without any trouble.

The article describes the installation in considerable detail. The apparatus is mainly of standard design, but special attention has been paid to the design of the suction valve (Fig. 5 D) as this feature alone, unless very carefully worked out, will nullify practically all of the benefits to be derived from such an installation. The admission of the high pressure gas from the piston ports is in the nature of an explosion and this at a time when the suction valve is wide open,

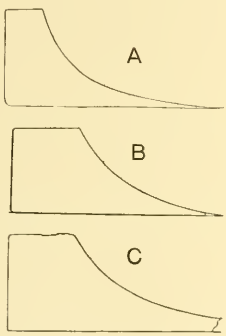


Fig. 5 A, B and C, Indicator Diagrams from Ammonia End of the Refrigerating Machine

resulting in a very forcible closing of these valves. Even with large area, low lift, good lubrication and quick action, in a design worked out for known local conditions, smoothness of operation begins to disappear at between 35 and 40 r.p.m. Speeds above 50 r.p.m. are attended with more or less valve slamming, rapidly increasing discharge temperatures and consumption of power.

Fig. 5 A, B, and C are reproductions of diagrams from the ammonia end of the compressor. Fig. A shows the compressor cylinders operating with low pressure gas; Fig. B shows the same with gas from the high-pressure system and Fig. C shows the machine operating with the combined gases. When the gases were combined, the piston ports, as shown by the indicator card, are also large enough to allow of the filling of the cylinder at speeds up to 50 r.p.m. before the piston has reached the end of its stroke. To the very small clearance is probably due the fact that there is practically no re-expansion of gases, it being possible to produce practically square corners on a card by feeding a few extra drops of oil to the cylinders per minute. (29 pp., 24 figs. *d.*)

## THE FRANKLIN INSTITUTE

*Journal, vol. 180, no. 2, August 1915, Philadelphia, Pa.*

The Effects of the End Connections on the Distribution of Stress in Certain Tension Members, Cyril Batho (abstracted)
Modern Theories of Magnetism, G. F. Stradling
Standardized Colored Fluids, H. V. Arny and C. H. Ring
An Investigation of Fusible Tin Boiler Plugs (U. S. Bureau of Standards)
The Testing of Rubber Goods (U. S. Bureau of Standards)

### The Effects of End Connections on the Distribution of Stress in Certain Tension Members. Cyril Batho

Investigation of the distribution of stresses in single or built-up structural members and its modification due to different types of end connections.

The paper describes in detail the very interesting method

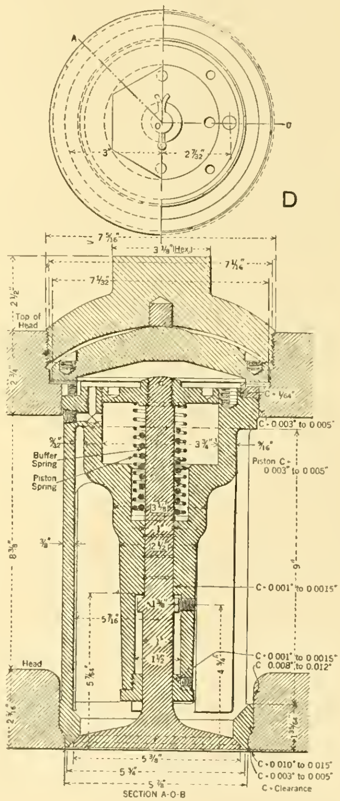


Fig. 5 D Suction Valve, Refrigeratino Machine

of investigation applied. The peculiarity of the latter lies in the use of a simplified form of Martens' mirror extensometer, constructed in the laboratories of the McGill University, Montreal. This instrument, while very simple in construction and operation, was shown to be capable, when certain precautions are observed in its use, of measuring strains accurately to 1/100,000 in. on a length as small as

2 in., and of being used in the most confined positions, such, for example, as the space between two angles placed back to back and separated by as little as $\frac{3}{8}$ in.

The paper further reports in detail Prof. L. J. Johnson's method of determination of distribution of strains, and among other things, his S-polygon, a figure which gives at a glance the point of maximum bending stress and the value of the latter for any given load axis. The author arrives at the following conclusions:

First. The only practicable experimental method at present available for investigating the distribution of stress in built-up members is by means of some form of extensometer, and the simplified mirror extensometer used in the tests described is very suitable for this purpose.

Second. The assumption of a planar distribution of stress is justifiable in such members as are considered here, except perhaps close to the end connections, and the ordinary theory may therefore be applied to an analysis of the distribution of stress in these members.

Third. In single- and double-angle tension members connected at their ends by means of rivets to wide and rigidly held gusset plates, the stiffness of the gusset plate in its own plane has a considerable effect on the distribution of stress in the member, there being in every case a particular stiffness which will give the least maximum stress in the member for a given load.

Fourth. In such members lock angles are of very little, if any, value for the purpose either of giving a more equable distribution of stress in the member or of increasing the effective length of end connections.

Fifth. A slight change in the line of application of the load to the gusset plates does not materially affect the distribution of stress in the member, except possibly close to the end connections.

Sixth. The experiments on double angles bear out the theory that such members do not act as a single piece bending as a beam (44 pp., 22 figs., *etA*).

## SOCIETY OF AUTOMOBILE ENGINEERS

*Bulletin, vol. 8, no. 4, July 1915, New York City*



### FUNDAMENTAL PROBLEMS OF ENGINE DESIGN, A. P. Brush

Discussion of the fundamental problems of engine design, mainly with regard to what would be the best engine for a modern automobile.

The author, together with the majority of automobile engineers, assumes that the small-bore, long-stroke, high-speed motor is the best adapted to automobile service, at least pleasure vehicles. This is because it satisfies the two fundamental requirements,—low weight and flexibility. The latter has to satisfy demands through a range unapproached in any other service since if 3 to 60 m.p.h. be accepted as reasonable minimum to maximum road speed on top gear, there is a 95 per cent speed fluctuation and all through this speed range the motors must operate satisfactorily from zero to full power.

As regards the most advisable length of stroke, the author points out that to meet the demands for flexibility, a power curve must be secured that will give good values above 2500 r.p.m. This gives what might be termed the valve-chamber-limit on stroke, because with an assumed form of cylinder and combustion chamber, the valves are limited to an outside diameter slightly less than one-half of the bore of the cylinder and to a throat diameter further reduced by the width of the valve seat.

As regards the connecting rod length, the time-factor as effecting combustion chamber efficiency requires a short connecting rod. The time-factor is most prominent during the latter portion of the compression and the earlier portion of the working stroke. Due to its angularity, the shorter the rod, the less the time proportion of the compression and working strokes coincident with high pressures, high temperatures and high wall-to-volume ratios. Therefore, the shorter the connecting rod the higher the combustion chamber efficiency at any given number of revolutions per minute.

As regards the mooted question of the number of cylinders, the author points out that the problem of increasing the power and flexibility of an automobile on top gear is solved, with the least reduction in efficiency, by increasing the number instead of the size of the cylinders, besides which the frequent impulse engine is more pleasing to the driver in its operation throughout the entire speed range; but there is a price to be paid for it, as there is an increase in mechanical complications. In particular regard to V-motors, the author calls attention to the fact that if all cylinders were worked properly on a single crank throw, all major vertical vibratory tendencies present in the vertical motor would disappear and in their place would be found horizontal vibratory tendencies which are twice as great as the vertical vibratory tendencies of the vertical motor. In the V-12 there are the same major vibratory tendencies as in the vertical 6; that is, instead of a tendency to reciprocate the entire motor mass with four reversals per revolution of the crankshaft, as in the vertical four and V-8, there is a tendency to set up periodic vibrations within the motor mass, the amplitude of these vibrations being in proportion to the work the engine is doing.

In the discussion which followed, C. W. McKinley stated that he had run some tests of two engines of practically the same volumetric capacity, one of which had an almost spherical combustion chamber and the other one pancake shaped which had practically as large a surface as it was possible to make, allowing proper gas flow over the valves. With both of these motors exactly the same horsepower was secured and the speaker therefore believes that the shape of the combustion chamber has very little effect on the ultimate power of the motor.

Victor W. Pagé called attention to the fact that the multiple cylinder engines take very much more time to repair and that for example in valve grinding, the probable expense would be \$2.00 to \$3.50 to grind in eight valves on a four; \$4.00 to \$7.00 for the valves on an eight and \$6.00 to \$10.50 for the valves on a twelve. He believes therefore that the car owners will feel it also after having paid several "twin-multiple" repair bills.

David Furguson spoke of a test recently conducted by the Pierce-Arrow Company. One of its 2-ton trucks using a standard 4-cylinder 4 by $5\frac{1}{2}$ in. engine with a standard worm gear having ratio of 7 to 1, did, on a long run, 7.25 miles per gallon of gasoline. A similar machine with an imported high speed engine of one-half the cylinder volume, geared 14 to 1, was run alongside the standard machine and

did only 6.6 miles per gallon. The speaker asked, therefore, if high speed multiple cylinder engines are more efficient than medium speed 4-cylinder engines, why are the six, eight and twelve high-speed engines not used on trucks, in the case of which economy is of so much moment?

D. McCall White, in speaking of the number of cylinders, urged the development of the small high-speed four, and strongly deprecated the stampeding (of which there is evidence) by some companies who manufacture the lower-priced class of automobiles, into the building of eights. An eight must be of the highest and most expensive type of manufacture. It is easier and cheaper to build a good high-speed four than a bad high-speed eight, and a good four will be more satisfactory to all concerned than a cheap eight. As regards the sixes and twelves, the speaker is of the opinion that, given the same rigidity of bearings on cam shaft and crank shaft, their mechanical efficiency is not so good as that of the four and eight.

Howard E. Coffin stated that the requisite number of cylinders depends entirely on the size of the car. The question is not whether a four, six, twelve or sixteen cylinder engine should be built, but how large the individual cylinder shall be. If the piston displacement is over 300 cu. in. it can properly be broken up into a greater number of cylinders than six, but where the total piston displacement is less than 300 cu. in., it is foolish to break it up into more than six cylinders.

Howard Marmon stated that he had never seen an eight or twelve do things that a six will not do, except possibly some of the "stunts." Speaking of vibrations, he called attention to the fact that the eight cylinder transforms the purely vertical vibration into a horizontal one. The vertical vibration is taken up by the springs, which have a slow period. The chassis is rigid laterally. Any rigid structure will transmit high frequency vibrations as the cross vibrations will necessarily be, and the speaker's opinion was that the cross vibration of the eight was very much more pronounced than the vertical vibration of the four (25 pp., *g*).

### A Formula for the Comparison of Gasoline Automobile Performance, Theodore Douglas

Discussion of a formula which would make it possible to compare various motor vehicles. It gives the following expression for the vehicle coefficient:

$$\text{(A)} \qquad VC = \frac{8.4nb^2sR}{DW}$$

where $n$ = number of cylinders; $b$ = bore in inches; $s$ = stroke in inches; $R$ = gear reduction; $D$ = diameter of driving tires in inches; $W$ = total weight of vehicle and load in pounds.

In addition to that, $VC$ is multiplied by $e_m$, which represents the efficiency of the motor compared with the NACC rating as unity, and by $e_t$ which represents the efficiency of the transmission system, so that the formula becomes

$$\text{(B)} \qquad VC = \frac{8.4nb^2sR}{DW} \times e_m \times e_t.$$

$VC$ is the ratio of the effort in pounds which the motor can exert at the driving tires to the total weight in pounds to be moved. If multiplied by the weight $W$, it will give the actual propelling force in pounds exerted at the tires of the driving wheels. $VC$ is the measure of the ability of the motor vehicle to propel itself. It represents the very important inter-relation of the motor displacement, the gear reduction, the diameter of the driving wheels and the total weight to be moved. The motor speed at any given vehicle speed is determined by the relation of $R$ and $D$. This formula further affords a ready means of comparing the practical effectiveness or ability of motor vehicles to perform their transportation function.

The terms $e_m$ and $e_t$ may not be definitely known, but can be quite accurately determined experimentally and for the average well-built car the product of these two terms will be about 95 per cent. If this factor be used formula (B) becomes

$$\text{(C)} \qquad VC = \frac{8nb^2sR}{DW}$$

The author gives the results of applying (C) to a number of well-known cars using $W$ as the weight of the car with full road equipment plus 150 pounds for each person the car is designed to carry. The above formulae are intended to be used primarily for the reduction on high gear, but can be applied to lower gear or intermediate reductions after making allowances for an adidtional loss in the gear box. The author also considers in detail the various resistance items such as road surface resistance, grade resistance and wind resistance. (7 pp., *gpt.*)

## SOUTH AFRICAN INSTITUTION OF ENGINEERS

*Vol. 13, no. 11, June 1915, Johannesburg, South Africa.*

Test of the Largest Air Compressor, G. M. Clark
The Influence Moisture in the Air has on Mine Ventilation, Arthur C. Whittome (abstracted)
The Centrifugal Pumping Plant of the Durban Roodepoort Deep, Limited, E. G. Izod and A. P. Rouillard

### The Influence Moisture in the Air Has on Mine Ventilation, Arthur C. Whittome

Discussion of the amount of air which has to be supplied per man, the influence of the presence of water vapor on that man and the effects on mine ventilation. As an example, a case is taken for which certain assumptions are made, and it is shown how the amount of moisture affects the results obtained.

The objects of ventilation (in particular, mine ventilation) are, *first*, to sweep all deleterious gases out of the ventilated zone; *second*, to supply to the working places such weight of oxygen as may be required by the workers therein, and *third*, in some cases, to lower the temperature of the working places to such a degree as to make work possible in spots which would otherwise be too warm. The author uses the term "oxygen stuff" to denote the pure dry-air portion, consisting of oxygen and nitrogen, of either dry or saturated air. He compares data on the amount of air breathed in by a grown person hard at work as given by various authorities, but points out that the primary object of ventilation is the provision at every place of such a weight of oxygen stuff as will insure an atmosphere suitable for breathing and not merely a supply of a stated volume of air.

This makes the question of the presence of moisture in the air of high importance, since as the author has shown in tables and curves, under a given barometric pressure, oxygen stuff decreases and water vapor increases in weight per cubic foot as the temperature rises. Further, as the temperature of the saturated air rises, the elastic force of the

water vapor increases, and, therefore, with saturated air at a constant pressure, the elastic force of the oxygen stuff will gradually decrease with increasing temperature, showing the second cause for the decreased weight of oxygen stuff in saturated air. The weight of saturated air is lower per cubic foot than that of dry air at the same temperature and pressure, and with constant pressure and increasing temperature, saturated air decreases in density at a more rapid rate than does dry air. To illustrate the effects of moisture on mine ventilation, the author takes a case for which he makes the following assumptions: *a.* The collars of the upcast and downcast shaft are located on the same horizon, the shafts being sunk to a vertical depth of 3000 ft. and connected by a single drive at the 3000 ft. level; *b.* In each shaft, the mean barometric pressure is 13 lb.; *c.* Mean temperature in the upcast shaft is 90 deg. fahr., and in the downcast shaft, 60 deg. fahr.; *d.* The following alternative contents of humidity are assumed as being possible: *first,* the air remains dry during the passage through the mine workings; *second,* the air is kept constantly 100 per cent saturated at all points in its passage, and *third,* the air is dry during its passage through the downcast and saturated during its passage through the upcast shaft.

An investigation of the conditions prevaiing in such a case shows that in the event of a constant mean temperature in the downcast shaft and a second constant mean temperature in the upcast shaft, the following rules will hold good: *first,* the least weight of oxygen stuff flows when the air throughout both shafts is perfectly dry; *second,* the greatest weight of oxygen stuff flows when the air in the downcast shaft is perfectly dry, and that in the upcast shaft is 100 per cent saturated; *third,* increasing the degree of humidity of air in the downcast shaft without lowering its temperature decreases the weight of oxygen stuff flowing; *fourth,* increasing the degree of humidity of the air in the upcast shaft without lowering its temperature increases the weight of oxygen stuff flowing; *fifth,* the greatest intensity of draft produced by natural means is obtained when no heat is abstracted from the air itself except in the downcast shaft (i.e., when water is only sprayed into the air into the downcast shaft, which does not mean, however, that the author advocates the disuse of sprays and water blast where these are necessary for the laying of dust or the absorption of deleterious gases).

There is one more aspect to the question of the presence of moisture in the air. It would seem that when a person breathes saturated air at a temperature above blood heat, there must be condensation of water vapor in his lungs and the resultant water, (almost certainly carrying deleterious gases and matter if the person is in a mine) must have a detrimental effect on the lungs and retard them in the efficient performance of their function. The author thinks that what is generally attributed to "laziness" developed by dark places and the impossibility of continuous supervision, should really be ascribed to the inability of the lungs to handle the extra volume of air which is requisite to provide the necessary weight of oxygen, the lungs being to some extent water-logged by condensed water vapor and by the moisture which would normally be absorbed by non-saturated air in its circuit in the body, but which cannot be taken up by the saturated air.

The following are some of the further conclusions arrived at by the author:

1. Air should be cooled as much as possible before it goes to the downcast shaft; while it is being cooled, it should be kept as dry as possible unless the heat used to evaporate the water is abstracted from the air, thus lowering its temperature and making it denser.
2. Water having been once used for spraying purposes in situations where deleterious gases are absorbed should not be used again for spraying, as some of the entrained gases will be released to the atmosphere when a portion of the water is evaporated.
3. Carbon dioxide absorbed by the spray water should be removed therefrom before the water goes to the pumps, in order to avoid corrosion in the pumps and piping.
4. If there are ill effects caused by inhaling hot saturated air, the air should be cooled before going to the working places. This could be effected by the installation of small electrically driven refrigerating plants at necessary points in the mine, and passing the ventilating air through cooling chambers. (8 pp., 4 sheets of tables and charts. *peA.*)

## CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

## NECROLOGY

### JOHN BROWN HERRESHOFF

John Brown Herreshoff was born in Bristol, R. I., in 1841. An attack of infantile glaucoma destroyed his sight, but his education was carried on in the schools of his native town. His bent for mechanism revealed itself at an early age, and the handicap of total blindness seemed to serve as a spur to his tireless energy. The miniature craft that he built and rebuilt in those early years served as the foundation of the skill and knowledge that he later turned to such good account.

At the age of twenty, he began the construction of larger craft, and in 1863 he embarked on naval construction as a business, which he carried on for more than fifty years.

In 1872, he entered into partnership with his brother, and together they designed and constructed for the U. S. Government the first torpedo boat, The Lightning.

In 1879, Mr. Herreshoff and his brother incorporated the Herreshoff Manufacturing Company, of which he was president and treasurer from its formation to the time of his death.

In 1892, the Herreshoff Manufacturing Company took up the designing and construction of yachts, with special reference to building craft that would enable the New York Yacht Club to hold the trophy against attack. The record of the Vigilant, Defender, Columbia, Reliance and Resolute indicate to what height of perfection Mr. Herreshoff's firm has carried the science of naval designing and construction.

Mr. Herreshoff was a member of the Institute of Naval Architects of London and a member of the Society since 1884. He died on July 20, 1915.

### WILLIAM H. GERRISH

William H. Gerrish was born in Lowell, Mass., in 1865, and was educated at the Lowell High School and the Massachusetts Institute of Technology. He served his apprenticeship at the Lancaster Slate Company, Lancaster, Mass., from 1888-90. For several years he held a position in the drawing room of the Massachusetts Cotton Mills, Lawrence, Mass., and at the Fulton Bag Mills, Atlanta, Ga.

During the Spanish-American War he was associated with the ordnance department of the War Office, Washington, D. C.

In 1899, he became superintendent of Barber Flax Spinning Company, Paterson, N. J., from which he went to the Dolphin Jute Mills, Paterson, N. J. Four years later, he came to New York as superintendent of Commercial Twine Company.

In 1910, he was appointed smoke inspector for the State of Massachusetts, which office he retained to the date of his death.

He was a member of the Order of Masons and the Royal Arcanum. He died on July 15, 1915, in Malden, Mass.

### EDWARD THOMAS MORRIS

Edward Thomas Morris was born in Lutterworth, England, in 1863. He was educated in public and private schools in England, after which he served his apprenticeship at Ruston & Proctor, engineers and boiler makers, Lincoln, England, from 1880-1884. During his apprenticeship he took night technical courses.

From 1884 to 1885, he was under instruction at the firm of J. & J. Thompson, marine engineers and boiler makers, Glasgow, Scotland.

From 1887 to 1888, he was outside erector of machinery for the Union Iron Works. From that date until 1899 he was superintendent of the marine engineers department of the Union Iron Works, having charge of the installation of boilers and machinery on the U. S. S. Charleston, San Francisco, Monterey, Olympia and Oregon.

From 1899 to 1900, he was assistant to the marine superintendent of the Pacific Mail Steamship Company, and from 1900-1902, general superintendent of the Fulton Engineering and Shipbuilding Works.

During the years 1902-1905, he was superintending engineer of the Oceanic Steamship Company, and in 1906 he became superintendent of construction with the Tracy Engineering Company.

From 1908-1911, he was engineer of construction for the Associated Pipe Line Company. In 1911, he was appointed manager of the Pipe Line Department of the Associated Oil Company, in which position he was in charge of the construction and operation of pipe lines and pumping stations of both companies.

Mr. Morris died in Oakland, California, on May 14, 1915.

### GEORGE RIPLEY STETSON

George Ripley Stetson was born in Brooklyn, Conn., in 1837, and was the son of parents who were prominently identified with the anti-slavery and other reforms of the time. His early education was received in Brooklyn, Conn., and in Florence, Mass. His subsequent education was gained entirely through his own effeorts without attendance at school.

In 1855, he entered a machine shop in Northampton as an apprentice. After completing his apprenticeship, he engaged in the manufacture of britannia ware. In 1864, he entered the employ of O. F. Winchester, manufacturer of rifles and ammunition, where he remained eight years.

In 1877, Mr. Stetson became superintendent of the Morse Twist Drill and Machine Company, New Bedford, Mass.

While in the service of this company and the O. F. Winchester Company he patented a number of devices which proved of value, receiving thirty-six patents for his inventions.

In 1890, Mr. Stetson became president and general manager of the New Bedford Gas & Edison Light Company.

He was a member of the Sutton Commandery, K. P., and a charter member and past patron of the New Bedford Chapter, No. 49, O. E. S. He was an active member of the National Electric Light Association and the Association of Edison Illuminating Companies, frequently representing these organizations as a delegate, and a charter member of the Society. He died on July 26, 1915.

### HAROLD BENTLEY ANDERSON

Harold Bentley Anderson was born in 1878. He received his technical training at the Case School of Applied Science in Cleveland, Ohio, and while in college worked up a motorcycle and also a sewing machine driven by a small gasoline engine. By the time he left college he had completed an automobile and in 1901, he secured patents on two automobiles. He at once entered the employ of the American

Bicycle Company in Toledo, producing a system of double acting brakes and the steering gear that was used on the copy of the "Lifu" truck, made in Toledo.

In 1902, he became associated with The Winton Company as personal engineer for Mr. Winton. In 1904, he was made chief engineer of The Winton Company, which he held at the time of his death.

Mr. Anderson was a member of the Society of Automobile Engineers, American Institute of Metals, American Society for Testing Materials, International Association for Testing Materials, Cleveland Engineering Society, Beta Theta Pi, Theta Nu Epsilon, Cleveland Yacht Club, Cleveland Automobile Club and The Aeronautical Society. He was also an officer of the aero squadron of the First Aviation corps, New York City. He died on July 13, 1915.

## PERSONALS

Edwin G. Hatch, consulting engineer, New York, will have charge of the inspection and testing of a 9000 k. v. a. transformer now building at the Westinghouse Electric & Mfg. Company's plant, East Pittsburgh, Pa., for the Victoria Falls and Transvaal Power Company of London. Five similar transformers were shipped to the company's plant in South Africa in 1912.

Dr. Addams Stratton McAllister resigned on August 1 his position as editor of the "Electrical World," New York.

F. M. Feiker, formerly associated with "Factory" and "System" and for the past few weeks with the "Electrical World" editorial staff, will succeed Dr. McAllister as editor of the "Electrical World."

Morris Knowles, consulting engineer, has acquired the engineering business formerly conducted from offices in Pittsburgh, Pa., and Canton, Ohio, by Mr. L. E. Chapin, recently deceased. Mr. Knowles, who was previously associated with Mr. Chapin, will conduct the combined business from his office 2541 Oliver Building, Pittsburgh, continuing to specialize in water works, water power, sewerage, sewage treatment and disposal sanitary investigation, town planning, flood prevention and valuation work.

Joseph A. Whitlow has been appointed chief of the Department of Gas, Electricity, Heat and Water for the Public Service Commission of Missouri. He was formerly chief engineer of the Board of Education of St. Louis.

H. T. Woolson, formerly chief engineer of the Gas Engine & Power Company and the C. L. Seabury & Company Consolidated has accepted a position as truck engineer of the Packard Motor Car Company, Detroit, Michigan.

Frank B. Gilbreth who is conducting a three weeks course in motion study in Providence, R. I., recently held an annual conference with a number of educational men and women from all parts of the country who are interested in the problems of scientific management. The meetings of this year have special significance in that Mr. Gilbreth has been asked by the governments of England, France and Germany to study the problems of efficiency with the view to considering the opportunities which are open to the mutilated soldiers in the present war.

Dr. John A. Brashear, President of the Society, has been chosen by Gov. Brumbaugh as the greatest Pennsylvanian. This selection was the result of an invitation from the officials of the Panama-Pacific Exposition to select a man upon whom the exposition could confer an honor as being eminent in the life of Pennsylvania. The governor not wishing to make the selection himself, decided to let the choice rest with the editors of the state and sent a letter to the journalists asking them to make the selection, and as a result Dr. Brashear was chosen.

## EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

### POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. In sending applications stamps should be enclosed for forwarding.*

0205 Draftsman experienced in the designing of bending rolls. One who has actually done work of this character. Location Southern States.

0206 Young engineer for research work of experimental nature, along general methods which have been partially developed. Must have fairly good command of mathematics and particularly adapted to contrive and carry out the mechanical work incident to the experiments. Position offers exceptional opportunities for the development of individual ability. Approximate salary to start will be $75.00 per month. Location Philadelphia.

0208 Designing engineer in drafting room of Boston concern. Prefer young man with some experience on conveyor work, though such experience is not absolutely necessary.

0209 Salesman for New York concern manufacturing rubber belting and rubber goods for mechanical and manufacturing purposes.

0210 Designer of special and automatic machinery and production tools. Give age, experience, and salary expected. Location New York.

0211 Young engineer with two or three years experience, for work in superintendence and operation of buildings. Location New York.

0213 Two designers with initiative in development work, machinery design, etc. Familiarity with automobile work desirable but not essential.

0220 A capable man, preferably with engineering education and good shop training capable of specifying equipment, to sell metal working machine tools in the Middle West.

0221 A man familiar with presses and forging machinery capable of selling same. Location Middle West.

0223 Department of Mechanical Engineering, Canadian University, invites applications for the position of lecturer in mechanical subjects, mechanics of machines and machine design, or shop practice and laboratory assistant. Applications should be accompanied by a statement of age, qualifications and salary expected.

0225 Mechanical draftsman; some experience in cane or beet sugar refinery; for two or three months work. Salary $5.00 per day. Location Louisiana.

0226 For firm in New York State, experienced mechanical engineer, who is thoroughly posted in stamping and drawing propositions.

0227 Designer with a broad experience on metal-working machinery and tools wishes to get in touch with a concern which would undertake the manufacture of new line of medium sized machines. Location Middle West.

0228 Draftsman, American; familiar with design and shop work. Position part time in New York State and later in New York City. In applying, state experience, etc. Salary $100.00.

0229 Inspector of machinery same line as 0228. Apply same as position 0228.

0230 Factory manager of more than ordinary experience in automobile manufacture for a company organizing for manufacture of automobiles. Name confidential.

0233 The direction of fire and patrol service about to be reorganized along most modern lines by a large automobile manufacturing company, is now open to a man who is qualified to take charge, who can shoulder the responsibility of custodian of their huge investment in plants, machinery and stock, with absolute integrity and fearlessness; a sane and healthy view of human nature; alertness rather than suspicion; understanding of various nationalities and types of men and their ways; ability to select a body of good men; to maintain proper discipline and to communicate a large sense of responsibility. Address 0233, care of The Am. Soc. M.E.

0234 A large industrial corporation manufacturing a diversified product including automobiles, desires a works manager for its machine shops, foundries, forge plants and other factory interests. A man of proven ability as an operating executive is sought; his record must demonstrate that his abilities combine a wide mechanical experience with the gift of organizing and obtaining the best from large bodies of men, a selective insight into efficiency methods, an analytic grasp in handling a large mass of detail, a true conception of how and what to delegate and a comprehensive understanding of the problems of the employee. Address in strictest confidence, P. O. Box 450, New York.

0235 Master Mechanic for a cotton piece goods finishing plant. First and principal requirement that he be well educated and preferably a technical graduate. Experience in finishing business not necessary, but ability to handle men and lay out the work of a machine and carpenter shop, piping and electrical department essential. Excellent opening for a man of ambition and energy. Location New England. Apply by number.

0236 Plant Manager for large silk weaving mill, who can lay out buildings and power plant and take charge of maintenance. Apply by number.

0237 Young graduate mechanical engineer to go into heat, light and power department of a plant employing about 1200; will be expected to be able quickly to take charge of the both steam and gas engine departments. Apply by number, giving age, education, experience and salary expected. Location New England.

0238 Young graduate engineer preferably with some experience in machine shop or construction work, to go into the time study and rate fixing department of a large plant in New England; will be expected to learn the business and will then be promoted into the operating departments in an executive office. Apply by letter, giving age, education, experience and salary.

0239 Young man, preferably one who has attended an engineering college, with a knowledge of machine shop practice, to enter the repair department of a large concern as assistant to the master mechanic. Location New England.

0240 Wanted, superintendent for munition shop, one with sufficient experience in the manufacture of six inch (and over) high explosive shells, to design a building, equip it with suitable machinery and operate the same after completion. Plant to be built within 25 miles of New York. Give references as to ability and experience. All communications confidential.

## MEN AVAILABLE

*The published notices of "men available" are made up from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.*

I-240 Member, who has designed, built, installed and operated hydraulic, conveying, woodworking, hoisting, computing, combustion, power transmission and other apparatus, mechanical and electrical, wants position with thoroughly established corporation in N. E. or near N. Y. City, in which a good salary may be earned several times over by the systematic introduction of economies and "short cuts" in men, methods and machinery between coal pile (or water power) and shipping room. Immediate salary of less importance than congenial position in which brains, experience and loyalty will assure fair returns to self and family based on results obtained.

I-241 Works manager or general superintendent, mechanical engineer, graduate of the Mass. Inst. of Technology, with 16 years experience in the manufacture of boilers. At present employed, having charge both of office and shop. Has produced results and can show a clean record. Address through the Society.

I-242 A mechanical engineer, technical graduate, with broad shop and mill experience, desires to become associated with an important New England concern. Full particulars exchanged.

I-243 Technical graduate, with seven years experience in design and construction, desires position with architect or engineer to take charge of service work including power plant, heating, plumbing, lighting and allied branches. Experience in railroad terminals and shops, theater, factory, church and residence work.

I-244 Technical graduate M. E., thirty years old. One year mechanical engineer with railroad. Six years experience with car manufacturer, designing dies, tools, heavy machinery, hydraulic presses; also projectile forgings. Good shop experience. Would be useful as assistant master mechanic or mechanical engineer. Location immaterial.

I-245 Member, age 37, sales engineer technical training, practical mechanic with a successful sales record; speaks Spanish and is conversant with South American trade conditions, forceful Spanish advertising, cataloguing, open for engagement in South American field with a responsible company manufacturing machinery, steel products, hardware or agricultural implements. At present connected with prominent Eastern jobbing house as department sales manager. Salary expected secondary to future prospects.

I-246 Position wanted as foundry superintendent or manager of works doing mostly foundry work; can furnish references satisfactory as to ability from previous employers. Practical foundry man who has filled all positions from laborer to the management of some of the most up-to-date companies in this country. Understands the business end as well as the practical end of the iron and brass foundry business.

I-247 Junior, technical education, with twelve years experience in designing, estimating, constructing and selling all kinds of mining, crushing, cement making machinery and complete plants, desires position.

I-248 Mechanical engineer, college graduate, associate member, 7 years practical experience, 31 years of age, married. Experienced in time study, rate fixing, steam engineer, master mechanic, mechanical superintendent. Salary $2,400.

I-249 Member, 28 years practical and executive engineering experience in designing, manufacturing, production, organization of manufacture, equipment, etc., modern shop practice and management, desires position as general superintendent or works manager, two or five year contracts only considered. Large experience in precision and quantity manufacture and expert in economical production.

I-250 Member of the Society, with eight years practical experience in general mechanical engineering, and four years experience in the installation of scientific management, wishes a position as efficiency engineer with a progressive concern.

I-251 Junior, age 21, two years at Cornell, two and a half years shop and drafting room experience, wants position in testing, engineering or manufacturing department where there is a good chance for advancement. Willing to work hard and study to obtain advancement. Salary to start, a secondary matter. At present employed.

I-252 Member, graduate Stevens Institute Technology, 13 years experience in design and construction, steam-electric plants, pumping stations, industrial works, heavy foundations, involving pneumatic caisson methods, reports and appraisals, also business experience, is open for engagement.

I-253 Sales engineer with seven years experience in power plant and water works fields; can furnish proofs of ability; would consider a similar position or connection with consulting engineer's office. New York City preferred.

I-254 Associate Member, technical graduate, age 33, nine years shop, erecting, designing and operating experience in the steam engineering field, having specialized in the design and manufacture of steam turbines; capable of taking full charge of same. Location immaterial. At present employed.

I-255 Junior Member, graduate mechanical engineer Stevens Institute of Technology; three years experience and now occupied in fire protection work, engineering and sales; familiar with insurance and factory conditions, desires to associate with insurance company, firm of brokers or insurance engineers having department making a specialty of improved risks. Location in New England preferred.

I-256 Junior member, technical school graduate, with five years engineering experience, 3½ years in present position as assistant mechanical engineer in large government engineering testing plant, desires position with testing department of large corporation, power station or engineering firm; capable of conducting complete tests of steam boilers, engines, turbines and all auxiliary machinery. Would accept $1800 to start.

I-257 Member, technical graduate, 12 years experience in design and supervision of heat, light and power plants, fuel and combustion, desires position as supervisor of power plants for efficiency, or designer with private corporation or consulting engineer. At present employed.

I-258 Graduate, mechanical engineer, associate-member, 4 years experience in designing, heating and ventilating plants; past 4 years in tests and experimental research work on steam boilers, gas, oil and steam engines, compressors, etc., as assistant professor in mechanical laboratory; at present employed in experimental department of oil engine maker; knowledge of German and French; desires to improve present conditions. Location immaterial.

I-259 Member, Cornell graduate, electrical and mechanical engineer; extensive experience in designing, constructing, operating, maintaining, inspecting, testing, and office engineering; desires position with engineering or manufacturing concern. Employed at present.

I-260 Member, 38, technical graduate, practical experience in various shop departments, also training from draftsman up to executive as treasurer and general manager; particularly well qualified for high-grade sales engineering; solicits opportunities from those seeking a country-wide market for product sold on quality rather than price basis. Has recently tripled volume of sales per dollar expended in repeated instances and has been particularly successful in the comprehensive organization and development of reliable sales forces. Would consider position of general manager if responsibilities were chiefly those of securing satisfactory market. Location immaterial.

I-261 Mechanical engineer, varied experience in technical advertising and editorial work, desires position as advertising manager of manufacturing concern. Location immaterial. At present employed.

I-262 Associate member, graduate of Massachusetts Institute of Technology, five years experience in laboratory and factory, wishes position as assistant to manager, superintendent or production engineer. Now employed. Opportunity first, salary secondary.

I-263 Member with broad manufacturing experience from apprentice to general manager in foundry, pattern, machine, blacksmith, boiler shops and drawing office, positions which called for initiative executive ability, tact, the handling of correspondence, organization of men and the direction of their work, wishes employment as manager, superintendent or other executive position. Location immaterial.

I-264 Associate-Member, graduate M.E., age 31, married, possessing strong personality with plenty of initiative and executive ability, having had seven years experience in machine shops, foundries, engineering, selling and efficiency work, desires to represent manufacturer in Chicago in a line of a technical nature where hard work and ability will produce a big volume of business. Available Oct. 1st.

I-265 Permanent responsible position wanted by an energetic, thoroughly practical and experienced shop and office engineer; Cornell M.E.; married; successful extended experience in the development of inventions, special and standard machinery, in plant management and as economy engineer.

I-266 Do you need the services of a man with a wide experience in the iron and steel industry? One who has had a good practical knowledge of shop and steel construction, as designer, engineer and contractor, for large independent steel companies, supplemented by three years as inspection engineer in charge of mill, shop and field inspection of structural steel, railroad rails and galvanized product. College graduate; age forty.

I-267 Member just returned from abroad would like to correspond with a well established concern (Middle West preferred) in view of securing a position as tool engineer or chief draftsman in full charge of the designing, building and manufacturing of tools, dies and machinery. Seventeen years experience with four of the largest and best known concerns in U. S. and Europe, on small, accurate interchangeable manufacture. Age 37, natural mechanical and executive ability, full references.

I-268 Junior, graduate, at present employed, five years design, manufacturing and power experience. Wants a live wire position.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of the Am. Soc M. E.

Aluminum Electrical Conductors. *Pittsburgh.* Gift of Aluminum Company of America.

America and her Problems. Paul H. B. D'Estournelles de Constant. *New York, Macmillan Co., 1915.* Gift of American Association for International Conciliation.

A series of essays based on extensive travels in this country. The author devotes much space to a discussion of economic conditions as he saw them. W. P. C.

American Society of Mechanical Engineers. Journal, vol. 36, 1914 (2 vols.). *New York, 1914.*

Boston Metropolitan Water and Sewerage Board. 14th Annual Report, 1914. *Boston, 1915.* Gift of Metropolitan Water and Sewerage Board.

Cost Reduction America's Only Salvation. An address by Robert Grimshaw before the American Supply and Machinery Manufacturers' Association, June 4, 1915. Gift of author.

Fall River Water Works. Report of the Watuppa Water Board to the City Council, Jan. 1, 1915. *Fall River, 1915.* Gift of Fall River Water Works.

Inschrijving voor 6625 Pakken Sumatra Tabak, te Rotterdam, op Zaterdag 26 Juni 1915, in het Algemeen Verkooplokaal. Gift of Universidad Nacional de la Plata.

International Association for the Prevention of Smoke. 9th Annual Convention, 1914. *Grand Rapids, 1914.* Gift of International Association for the Prevention of Smoke.

Investigation of the Concrete Road Making Properties of Minnesota Stone and Gravel. University of Minnesota Engineering Studies. No. 2. March, 1915. *Minneapolis, 1915.* Gift of University.

MacRae's Blue Book, 1915. *Chicago-New York, 1915.* Gift of MacRae's Blue Book Company.

New Jersey Harbor Commission. Annual Report, 1914. *Trenton, 1915.* Gift of New Jersey Harbor Commission.

New York State Constitutional Convention. Exercises in Commemoration of the Seven Hundredth Anniversary of Magna Charta, June 15, 1915. *Albany, 1915.* Gift of Constitutional Convention.

St. Louis Public Library. Annual Report, 1914-15. *St. Louis, 1915.* Gift of St. Louis Public Library.

Shrinkage and Time Effects in Reinforced Concrete. University of Minnesota Studies in Engineering. No. 3. *Minneapolis, 1915.* Gift of University of Minnesota.

Tensile Tests. Report made at the Watertown Arsenal, Watertown, Mass., on April 10, 1915. Gift of International Engineering Works, Ltd., Framingham, Mass.

Trade Education in Connecticut. Gift of F. J. Trinder.

University Club. Annual. 1914-15. *New York, 1914.* Gift of A.S.M.E.

Water Softeners as Applied to Central Station Heating Plants, F. F. Vater. Gift of author.

EXCHANGES

American Society of Refrigerating Engineers. Year Book, 1915. *New York, 1915.*

Society of Automobile Engineers. Transactions. 1914, vol. 9, pt. II; 1915, vol. 10, pt. I. *New York, 1914-15.*

TRADE CATALOGUES

Cummings Ship Instruments Works. *Boston, Mass.* Catalog, 1915. Cummings ship instruments.

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## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal

THE JOURNAL OF

# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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## ANNUAL MEETING, 1915

New York City, December 7 to 10

*Textile Session*: Papers on the relative values of individual power plants in textile mills and purchased electric current; hot water heating of textile plants, and engineering features of insurance.

*Railroad Session*: Discussion of trucks for passenger coaches.

*Protection of Industrial Workers Session*: Papers on safety methods in the engineering industries, compensation laws, economic advantage of safety appliances.

Papers contributed by the Committee on Machine Shop Practice, covering mechanical and electrical control of machine tools.

Papers contributed by the Committee on Industrial Buildings, dealing with building foundations.

Paper contributed by the Research Committee, on mechanical strength of porcelain and stoneware.

Papers contributed by Junior Members for the Junior Prize.

## MEETINGS OF LOCAL SECTIONS

*October* 6, *St. Louis, Mo.* Subject: The Little River Drainage District, by William A. O'Brien.

*October* 12, *New York.* Subject: Motion Study for Crippled Soldiers, by Frank G. Gilbreth, Mem. Am. Soc. M. E.

*October* 13, *Boston, Mass.* Joint meeting under the auspices of the A. I. E. E. Subject: Load Dispatch Board as used by the Edison Electric Ill. Co. and Boston Elevated Ry. Co.

*October* 21, *Buffalo, N. Y.* Subject: The Training of Young Mechanics, by W. B. Humper, Director of the Pittsburgh High School.

*October* 27, *St. Louis, Mo.* Subject: Telescopes, by Dr. John A. Brashear, President of the Society.

*November* 4, *Buffalo, N. Y.* Subject: Multiplicity of Cylinders in Automobiles, by J. G. Vincent, Mem. Am. Soc. M. E. and Vice-President of the Packard Motor Car Company.

*November*, *New Haven, Conn.* Subject and date of meeting to be announced.

*November* 19, *Chicago, Ill.* Subject of meeting to be announced.

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# THE SAN FRANCISCO MEETING

THE Society was notably represented at the national gathering of engineers in San Francisco last month to pay personal tribute to the builders of the Panama Canal, and its own September meeting was attended by a large proportion of the members resident in San Francisco and by others from all sections of the country. The meeting of the Society took place on Thursday, September 16, and Friday, September 17, three days prior to the International Engineering Congress, which convened on Monday, September 20.

The members of the Society who went out to the meeting from New York journeyed to San Francisco on the Engineers' Special which had been arranged for the convenience of the members of the National Engineering Societies visiting the Panama-Pacific International Exposition and the Engineering Congress. This train left New York on the evening of Thursday, September 9, carrying a party of 169 members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers and The American Society of Mechanical Engineers, with ladies and guests. The trip across the continent was made over the New York Central and Santa Fé lines, stops being made *en route* at points of scenic interest. Representatives of the various local committees of the Societies came aboard the train before it arrived at Oakland, Cal., to welcome the visitors and to assist in conducting them to their respective hotels. The party arrived in San Francisco on the evening of September 15.

The headquarters of the Society was the Clift Hotel, where registration was begun as soon as the party from New York arrived. The local arrangements were in the hands of the San Francisco committee, F. W. Gay, *Chairman*, F. H. Varney, *Vice-Chairman*, C. F. Braun, *Secretary*, H. L. Terwilliger and J. T. Whittlesey. Acknowledgment of the work of these gentlemen, which resulted in such a successful meeting, should be made.

The opening session of the September meeting was held in the Hall of the Native Sons of the Golden West at 10 o'clock on the morning of September 16, and the meeting and subsequent events are described in the following communication received from Calvin W. Rice, Secretary of the Society.

"The events since arriving have been the regular morning session on Thursday, opened by the President of the Exposition, Charles C. Moore, extending the welcome on behalf of San Francisco and the State of California, to which President Brashear responded. I have also sent the remarks prepared by Mr. Dickie, in reply to Mr. Moore. The remainder of the morning session was appropriately devoted to two papers bearing on the Exposition, one by Mr. Bayley, chief engineer of construction of the Exposition, who presented a comprehensive paper on the engineering features of its building; and the other by Mr. Dickie, dealing with the features of mechanical engineering interest embodied in the exhibits. After the session we all took busses to the Exposition grounds where a lunch was tendered by the local members. From the Old Faithful Inn, we proceeded in Fadgl trains around the Exposition grounds terminating in the Court of Abundance, where the President of the Exposition presented a commemorative medal. This was received by Dr. Brashear on behalf of this Society.

In the evening there was an informal dinner of the Civil Engineers in the Old Faithful Inn, and also a dinner-dance under the auspices of the Electrical Engineers at the Hotel St. Francis, to both of which functions our members were invited. At the latter function the President and Secretary and the Past Presidents of the Mining Engineers and Mechanical Engineers were present as guests of the Electrical Engineers.

Friday, at the professional session in the forenoon, the two papers on Oil and Diesel Engines by Messrs. Goldingham and Adams, respectively, and the one on Gear Teeth by Professors Marx and Cutter were presented, followed by an interesting discussion.

At the conclusion of this session, the Officers of the Society took a bus to the Exposition grounds, where we were the guests at a lunch tendered by the President of the Exposition. There were present, Dr. John A. Brashear, Jesse M. Smith, Geo. W. Dickie, Prof. W. F. Durand, Ira H. Woolson, Guy L. Bayley, Gano Dunn, W. R. Warner, John A. Freeman, W. L. Saunders, H. G. Reist, Chas. Whiting Baker, F. W. Gay and Calvin W. Rice of the Society; Mr. Lynch, Vice-President of the Chamber of Commerce; Mr. Arlett, representing the Governor of California; Mr. Mark-

wart, formerly Associate Director of Works and to whom much of the credit should properly be given for the construction work of the Exposition; Mr. Brown, a director of the Exposition; Col. Hetherington, Pennsylvania State Commissioner; Mr. Connick, Director of Works of the Exposition; Mr. Hardee, Director of Functions, and the two aides of President Moore, Lieutenant Commander Woodward and Captain Carpenter. Mr. Moore acted as toast master, and after a toast to the President of the United States and the Governor of Pennsylvania, welcome was extended on behalf of the Exposition authorities by Director Brown. Recognition of the engineer was given in connection with the rebuilding of San Francisco after the terrible conflagration, and that the successful completion of the Exposition was due to the Engineer.

Inasmuch as our President, Dr. Brashear, was the person designated by the Governor of Pennsylvania as the most distinguished citizen of that State, mention was made of that fact by Director Brown.

Mr. Arlett, representing the State, followed, and expressed a wish that all the engineers would obtain the vision which the officials had had before them in all their work in connection with this International Exposition.

Col. Hetherington next spoke, having gotten up from a severe illness in order to attend the luncheon. He stated that Pennsylvania had sent to the Exposition two great exhibits—the Liberty Bell and Brashear.

W. L. Saunders, President of the Mining Engineers, was next called upon and facetiously called attention to the fact that this was "Mining Engineers' day" notwithstanding that this luncheon was tendered to the Mechanical Engineers. Mr. Saunders showed the part that mining had played in the development of California's greatness, and in fact, California's contribution to the prosperity of the entire country.

Mr. Gano Dunn, President of the United Engineering Society, stated that while credit should be given the Engineer, we should also remember that it is the artist, the lawyer, and those moved by the religious instinct who should receive recognition, equal with the Engineer, for the imagination essential to the construction of any great work. It was essential for one to have an imagination in order to be considered as truly participating in life. A tribute was paid to President Moore, whom Mr. Dunn had seen three years previous in connection with the meeting then proposed for the International Electro-Technical Commission, and that Mr. Moore had made good his most ambitious promises.

Mr. Dickie was called upon in his capacity as one of our representative engineers, responsible for much of the engineering of the Coast.

Then followed Mr. Markwart, speaking for the engineering staff of the Exposition. He forcefully brought out that the Engineer did have all the imagination essential to the construction and execution of the Exposition—and to the dismantling besides. He had to imagine a lake and a swamp made into a city. In round numbers, the Exposition had cost \$18,200,000, \$14,000,000 of which had been expended under the direction of the engineering staff.

Dr. Brashear concluded the remarks by referring particularly to California's contribution through the Lick Observatory, and particularly urged engineers to have as their main motive of life that of helping others.

President Moore closed the luncheon by a toast drunk to the Progress of Engineering and Scientific Accomplishment.

Quite a number then accompanied President Saunders to the Court of Abundance, where ceremonies similar to those of Thursday were in progress, Director Brown, on the part of the Exposition, presenting a commemorative medal to the Institute of Mining Engineers.

In the evening, the A.I.M.E. held a successful banquet at the Palace Hotel at which the President, Secretary and Past Presidents of the Electrical Engineers and Mechanical Engineers were guests.

Next week are the events of the International Engineering Congress. Besides the professional sessions there will be on Monday evening, the Congress reception, and on Friday evening the Congress banquet.

On Wednesday, in honor of Dr. Brashear, they are to have "Brashear Day" at the Exposition, when we understand a medal will be presented to Pennsylvania's most distinguished citizen.

Friday, will be "Engineer's Day."

Calvin W. Rice, Secretary.

September 18, 1915.

## REPLY TO ADDRESS OF WELCOME BY CHARLES C. MOORE.

By Geo. W. Dickie, Mem. Am. Soc. M. E.

The duty of replying to your very kind address of welcome, devolves upon me as Vice-President of this Society. This, sir, is not the first meeting of this Society in San Francisco. On May 16, 1892, this Society began a memorable meeting in the reception parlor of the old Palace Hotel. There the members were welcomed to the Pacific Coast by his Honor, Mayor George H. Sanderson. Mr. Robert W. Hunt replied in graceful terms, and thus the meeting was formally opened. The local committee who made the arrangements for that meeting were Wm. R. Eckart, Chairman, Charles G. Gale, Secretary, G. W. Dickie, James Spiers, John Richards, Marsden Manson, E. J. Molera, H. J. Small and Frank Van Veck. Some of these have answered to the last call, while the others are still doing something to help along the things they think should never go to the scrap heap. It is very fitting, sir, that you should bid us welcome at this time, as we are here like many others to help celebrate the greatest engineering achievement of our time, the cutting in two of the Western Hemisphere, joining the two great oceans of the world, forming a new pathway for the world's commerce. Our great Exposition that celebrates the completion of this great work, has developed into a thing of wondrous beauty, with you, sir, as its guiding head. It is true that another engineering society will naturally claim first honors in the great work that we celebrate, yet it must never be forgotten that the civil engineer can not go very far in any work he undertakes without the active help of the mechanical engineer. If he wants to dig either a big or little ditch, and needs a shovel for the purpose, either an ordinary 25 lb. hand shovel or a fifteen ton steam shovel, he must get the mechanical engineer with him before he can do any digging, and at this time it is worth while remembering that nearly all the great work carried out under the civil engineer is necessary, because of what the mechanical engineer has been doing. The great steamships that originate with the mechanical engineer, made the Panama Canal a necessity. The locomotive engine, with its long line of cars, makes necessary the tunnels and bridges that the civil engineer constructs for their passage. In fact,

nearly all great modern works of which the civil engineer is so justly proud, have been produced in order that the work of the mechanical engineer may either run over or through them. The work of the civil engineer is more spectacular and more in the public eye, thus exciting admiration that is reflected on the designer and builder.

Sailing on one of the Hudson River day steamers, up that splendid river about two years ago, I saw ahead an airy structure spanning the river at a great height, looking like a huge spider web, too attenuated in appearance to serve any practical purpose, but as the boat came nearer, the stability of this structure became more apparent, and admiration of the boldness of it began to take possession of my mind, then something appeared at one end of this airy structure, and quickly took possession of it as a pathway to the other side. Here was the explanation of it all. The mechanical engineer needed the Poughkeepsie Bridge for his locomotive and train to cross the river, and he also needed the river for his steamer, and so we find as we contemplate the work of these great branches of engineering, that they are "Useless each without the other." The one is static, that is engineering in repose, the other dynamic—engineering in motion, and they are every day becoming more important factors in the work of the world. Even war has now become largely a job for the mechanical engineer, and seeing that we can neither live comfortably, nor die bravely without the help of the mechanical engineer, his position among the useful elements of society should be improved, so that he would occupy a place in the estimation of his fellow men commensurate with the indispensable character of the service he renders to the world. I would not seek a higher place for the mechanical engineer than that which is freely granted the civil engineer, but it should not be lower, and it is one of the functions of the Society that I represent here today, to help the mechanical engineer find his true place among the professional men of his time.

To the 6,000 members of this Society, the country is largely indebted for the position she occupies among the nations of the earth, that she is able to furnish other nations with so many implements through which progress is made, is largely due to the work accomplished by members of this Society. That the reward that comes to them financially is not what it ought to be is shown by the small percentage of our members who have been able to cross the continent, and see the wonderful dream that has become a fact, sir, under your direction—and attend the meetings to be held here. This is to be regretted, but cannot be helped. Engineers as a rule do not acquire wealth, and perhaps it is just as well for them that they don't—there would be less good work done if it were better paid for. The best work that has ever been done for this old, ungrateful world of ours, was never paid for. You can't do the things that you think ought to be done, if you wait for a contract insuring pay before you do them. Many noble engineers still do the things they love to do without any thought of pay, and so long as that is the case, we can well be proud of our profession. The present President of this Society is a splendid example of the character of man I refer to. It has often been said of the family I belong to, that they would rather build ships and starve, than do anything else and become rich, and I trust they will continue in that frame of mind. And now, sir, accept the thanks of this Society in the welcome you have given us to San Francisco, and in behalf of the members, here present, and the great number belonging to us all over this great country, we thank you very cordially for giving us your presence this morning, and for the kind words you have spoken to us on this occasion.

## PRESENTATION OF COMMEMORATIVE MEDAL, THURSDAY, SEPT. 16TH

On behalf of the Exposition, President Moore presented a commemorative medal to the Society in recognition of their having held their meeting in this City at the time of the Exposition. Opening remarks were made by Mr. Dickie, Vice-President of the Society, in which he emphasized the obligation of the world to the engineer. President Moore responded stating that as an engineer this was a hey-day of the Exposition and he expressed great satisfaction in being able to meet members of the Engineering Societies personally.

The Exposition was under great obligations to the Engineering Societies indirectly, and to the members of his staff, directly, for much of its success and beauty.

> "*God made the World, but the Engineer made it to live in.*"

One definition which appealed to Mr. Moore was that in our constitution "To adapt the achievements of arts and science to the use of man." President Moore stated that the purpose of the Exposition is to leave enduring high aspirations and high thoughts for the advancement in human brotherhood. The success of the Buffalo Exposition can be credited largely to Mr. Newcomb Carlton, an engineer, and similarly all the activities of this Exposition have been directed by engineers, in fact, the profession dominated the Exposition.

Dr. Brashear responded with heartfelt appreciation. He referred particularly to the monument to Samuel Pierpont Langley, which he had seen on the way to the Court of Abundance. He spoke of the progress of engineering and compared it to the strides in the art of photography. He had had a conversation, when a young man, with a woman who had sat sixty minutes for her photograph, and it wasn't so long ago when one had to sit seven minutes. Now we can not only take a photograph of the cannon ball going through space at the rate of 1500 ft. a second, but also can finish it quickly, as emphasized on this occasion, where a photograph of the company assembled had been taken and prints distributed before the ceremonies were concluded.

The work of the world is yet to be done. Sir Isaac Newton, at the time he was dying, stated that he was as a child who had simply gathered a few shells, whereas the whole ocean of truth lies before us.

After Dr. Brashear's response, Professor Durand followed with an address on the progress of mechanical engineering in the service of humanity.

## PROGRESS IN THE FIELD OF MECHANICAL ENGINEERING DURING RECENT YEARS

By W. F. Durand, Mem. Am. Soc. M. E.

I take it that, in its deeper significance, the ceremonial in which we are assisting this afternoon, is intended to signalize the work of the mechanical engineer in the service of humanity, and in this thought I shall refer briefly to some few of the larger fields into which we are called in this service, and to some of the more important achievements which have been made in these fields.

First in answer to the broad query, What is the field of service of the mechanical engineer? I like to picture him in mind as a great high priest of Nature whose duty it is to stand between the mighty stores of energy which she holds for the service of humanity, and the insistent demand for energy and more energy, as the one universal and essential element in the fabric of our present day civilization.

We have heard in history of the age of stone, the age of brass, of iron, of gold; but in a very real and literal sense the present is the age of energy, an age in which the entire fabric of our civilization is built upon the liberation and utilization of the inorganic agencies and energies of nature.

Pause only for a moment to consider our state, were there available for our present day life, no energy other than that which we might furnish by our own hands, or by the aid of domesticated animals. Consider the essential elements of our everyday life; the raiment we wear, the food we eat, the houses in which we dwell, the means for carrying on the complex systems of intercommunication between man and his fellow. Remove the supply and the methods and means for utilizing the energies of Nature for these purposes and what have we left? Our entire present civilization with its wonderful achievements and complex interrelations, crumbles away and disappears.

And so it is that peculiar function of the mechanical engineer to stand as the interpreter and the purveyor of natural energy in the service of humanity.

The sources of such energy are well known. Those with which we are chiefly concerned are, on the one hand, the hydro-carbon supplies, now existing in the form of gas, oil, or coal, and stored up in past geologic ages for our present day service, and, on the other, hydraulic sources, representing the present day energy of the sun in lifting the water into the air in the form of vapor, whence it is precipitated as rain or snow, collected on high mountain watersheds and ultimately, in seeking its lower level in the sea, may be made to turn our water-wheels and thus furnish energy in electrical or mechanical form as we may desire.

Again in serving the needs of civilization as the interpreter and purveyor of energy, the functions of the mechanical engineer are manifold and not easy of rational classification. Broadly, however, his field of work may be indicated under the following chief heads:

(1) The transformation of energy from the unavailable form in which Nature holds it, into the directly available or dynamic form as embodied in the motion of a prime mover such as a steam or internal combustion engine, steam turbine, or water-wheel; and the design, construction, and application of prime movers in special forms to the driving of steam ships, railway trains, or other special and direct modes of application.

(2) The transformation, by means of devices and mechanisms, of the mechanical energy furnished by a prime mover, into modes of motion suited to the manifold demands presented by the various industrial arts. Thus every machine driven tool for the forming of parts of other machinery or of structures, every mill and factory wheel, in short every cunning device of industry—all represent the application of a mode or means of transforming and thus utilizing mechanical energy.

(3) The organization and management of industrial systems, whereby, through the combination of mechanical energy, raw material and human directive agency, the products of the arts and industries may be most effectively provided.

While the work of the mechanical engineer is by no means hemmed in by the arbitrary boundaries indicated in these categories, and while either along or in co-operation with his brother engineers in other fields, he renders signal service to humanity, nevertheless the three categories noted above represent his most significant and characteristic fields of work and I shall refer, only briefly, to some of the notable achievements in these fields during recent years.

In the broad field of power development, the mechanical engineer has rendered some of his most impressive and beneficent service to humanity. In the transformation of the energy from hydrocarbon sources into mechanical form, there are two well known routes—that by way of water in the form of steam as an intermediate agent, and direct, as in the more recent internal combustion prime mover.

The present steam boiler represents a wonderfully refined engineering product. Having in view the conditions under which it must work it represents indeed a marvel of safety and efficiency. So long as we are limited by the present modes of combustion and heat transmission, the present efficiencies of 80 per cent. and upward leave but small margin for improvement. The special lines of advance during the past decade have been in the use of higher steam pressures, more reliable and effective means of producing superheated steam, a close and intensive study of boiler operating conditions resulting in marked advance in capacity, efficiency, and reliability; and finally, marked advance in our understanding of corrosive and deteriorating agencies, and in effective modes of control.

The reciprocating steam engine, as a prime mover, represents mechanically, in its present form, well nigh a completed and perfected mechanism. While in large sizes the turbine is becoming the typical steam prime mover, and while the internal combustion engine now occupies a considerable part of the prime mover field, nevertheless the reciprocating steam engine still holds its own for many purposes, and aside from the automobile engine is undoubtedly more numerously used than all other forms of prime mover combined.

The special lines of development which have signalized the progress in recent years have included the following items:

(1) Better adaptation to the use of superheated steam.

(2) The advent of the una-flow type of engine with a single cylinder, rivalling the results to be obtained by multi-stage engines using the older mode of steam distribution.

(3) Compact and highly efficient small steam power plant units of the so-called locomobile type.

(4) A careful study into and a better understanding of the conditions which determine the economical selection of

steam prime-movers, thus assuring wiser and more economical choice among the many types offered.

In the field of the steam turbine, the mechanical engineer with his brother the electrical engineer have produced, during the past two decades, a complete revolution in the field of power plant engineering, especially as applied to large central station service for electric light and power, and to marine propulsion in both the mercantile and naval services. Huge units are now possible, which a few years ago were far beyond the dreams of power plant engineers, and give at the same time efficiencies hitherto unattainable in steam prime-movers. The steam turbo-electric unit of 30,000 kw. has already arrived and a larger unit of 50,000 kw. is already peeping above the horizon. The progress in this particular part of the field stands out as a bold mountain peak, and when the history of the development of engineering during the early part of the 20th century shall be written, the advance in the application of the steam turbine will furnish one of its most impressive chapters.

No less significant and impressive has been the progress during the past 20 years, and in particular, during the past decade, of the internal combustion engine—the engine which uses gas, gasoline, distillate, kerosene, or crude and fuel oils as its own immediate source of energy. The automobile with all that it means to the world of today, depends for its present widespread service, on the successful solution of the problem of the internal combustion engine. Likewise the aeroplane, and indeed the entire field of heavier than air aeronautics, depends for its very existence on the marvelous refinements which have been wrought in the design of this form of prime mover during recent years. Again, unknown thousands of industrial, economic, and commercial demands for power in relatively small amounts are met effectively and reliably by engines of this type. Again and perhaps no less impressive than the advent of the automobile engine, has been the rapid development during the past decade of the Deisel engine—the engine which carries the prime mover back to the mouth of the oil well or in any case to a form of fuel of the same order of cost as the crude petroleum oil and which gives at the same time a thermal efficiency reached by no other class of heat prime mover. This engine is making rapid and significant progress in stationary practice where power is required in moderate amounts and where overall economy of the order of the steam-boiler steam-turbo plant must be equalled or bettered.

Still more spectacular is the progress of this type of prime mover in the field of marine engineering. Deisel engine power plants for marine propulsion of a horse power capacity in the thousands are now a commonplace of the field of marine construction, while the submarine, with its terrible powers of offence is dependent for its high surface speed, for power to charge its storage batteries for submerged cruising and for its relatively extended radius of action, on the power developed, and the efficiency realized by Deisel engines as perfected in recent years.

Again, in this connection, I should not omit to refer to the magnificent work which has been done in the field of railway engineering, in the improvement of the locomotive, the iron horse which draws our trains with their millions of passengers and countless tons of freight over the railroads which gridiron the inhabited land. In recent years the improvement here has been in refinement of design, improvement in economy and great increase in size and capacity. No more impressive sight perhaps is to be found in this Exposition, in the display of engineering progress, than the two locomotives, in the transportation building, one marking the early pioneer days and the other a modern representative giant of the iron rail.

In the same field likewise, the mechanical and electrical engineer have joined hands and have produced the wonderful electric locomotives now coming into use for special conditions of service, and of which we have in this Exposition a splendid example, nearby the steam locomotives to which I have just referred.

Turning for a moment to the field of hydraulic power engineering, we find in recent years progress, perhaps less spectacular than in some others, but none the less real. The improvements here are concerned with great increase in size, in efficiency, and in general reliability and adaptability in the various fields of service. Here again, joining hands with the electrical engineer, hydro-electric units of 15,000 to 20,000 h.p. capacity and upward, are readily built under suitable hydraulic conditions, and with hydraulic efficiencies close to about 90 per cent—achievements which 20 years ago would have seemed quite beyond the limits of possibility or immediate hope.

But I must hasten on to a few references to achievements in other fields of activity.

In the general field of devices and mechanisms for transforming and utilizing energy in accordance with the demands of the arts and industries, the imagination is staggered by the wealth of material and it is scarcely possible to know where to begin or where to end. One of the notable lines of progress has been in the field of automatics; mechanisms which seem scarcely less than human, and which, in the field of industry, eliminate or reduce to the barest minimum the residuum of human energy or directive agency required, and thus give us the manufactured article as a combination of little beyond raw material and mechanical energy. Again, to take here and there at hazard a few illustrations, mention may be made of the linotype and monotype machines for typesetting, the wonderful printing presses which give us our newspapers, magazines, and books, boot and shoe machinery which has revolutionized this industry in recent years, wonderful looms of the Jacquard type which weave articles of beauty and utility from the raw materials which are supplied, flouring machinery, sugar machinery, wood working machinery, metal working machinery of every kind and purpose, rolling mill machinery for making the steel plates and shapes of which are formed our ships, our bridges, our giant buildings, the rails on which our railroad trains may safely run, machinery for making pipe, tubing, rods, wire—in iron, brass, copper, and in the myriad forms, sizes and patterns which the modern arts and industries require.

These and countless more are all embodiments of ways and means for transforming and utilizing energy, and they represent one of the most diversified and most fruitful of the fields in which the mechanical engineer may serve his day and age. In all of these countless mechanisms, recent years have witnessed signal advance in scope, in adaptation, in economy, and in effectiveness relative to the ends in view.

Turning now, in closing, to the last field which I have mentioned, the organization of industry with reference to the highest economy of useful product, we find most notable advances during the past decade.

The so-called science of industrial management has at-

tracted increasing attention during recent years, and has been the subject of exhaustive studies on the part of many most eminent engineers.

In the accredited pioneer and distinguished leader in this field of work, The American Society of Mechanical Engineers, recognizes one of its own past presidents, Mr. F. W. Taylor, unhappily cut down in the midst of his usefulness in this field.

This is neither the time nor place to discuss in detail the science of industrial management and I can only say here, that as an ideal, it strives to so co-ordinate and combine the duties and responsibilities of capital and of labor, of the highly trained technicians and of the craftsmen in their various grades and degrees of skill, that the products of industry, representing the combination of (1) raw material, (2) human energy and directive skill, (3) mechanical energy, may be realized with the minimum demands on each of these three ingredients, and with the maximum financial reward, fairly divided among all who have contributed to the result.

In this field much of the fundamental work has been well started; much still remains to be accomplished. It is one of the most significant of the fields which have recently attracted the attention of the mechanical engineer, and the past decade will go down in the history of engineering progress as that which witnessed the special groundwork studies which should serve for the development of a wiser and more effective organization of our industrial agencies and forces.

In closing, I only repeat in other words my opening thought. The work of the mechanical engineer enters as an essential element into the daily life and well being of every dweller within the pale of civilized society—whether in sickness or in health, whether high or low in estate, rich or poor, and whether occupied in business or pleasure. It forms that part of the civilization of today which in a peculiar sense renders it distinctive and marks it out from the civilization of earlier ages.

In all this the mechanical engineer should recognize only an opportunity for service to humanity and to the cause of human progress. As mechanical engineers, let us see that we live up to the full measure of the opportunities for such service which are placed in our paths.

In the period remaining between the closing of this session and the International Engineering Congress, the members of the Society took part in a number of excursions to points of engineering interest, including the San Francisco High Pressure Fire System, the Portrero Gas Works, Station A of the Pacific Gas & Electric Co., the Spring Valley Water Works, the Great Western Power Company's Hydro-Electric Development on the Feather River, and dredging at Oroville, and the Spaulding-Drum Development of the Pacific Gas & Electric Company.

The International Engineering Congress opened its sessions on the morning of September 20. The proceedings of this Congress will be described in the next issue of The Journal.

The thanks of the Society are due to W. R. Cobleigh, who attended the September meeting, for the copy of the address by Prof. Durand sent to New York in time for publication in this issue, and to all others who contributed to the success of the September meeting.

## CORRESPONDENCE DEPARTMENTS FOR THE JOURNAL

The Journal publishes from month to month papers given at the annual and spring meetings and at many meetings of the local sections of the Society. Discussion upon these papers, however, is not restricted to the meetings. In order to secure the greatest possible benefit from the knowledge and experience of the membership, the discussions given at the time the papers are presented must be supplemented by contributed discussions from those who were unable to be present when the papers were read.

Accordingly, the Publication Committee has authorized a correspondence department for discussions upon technical subjects relating either to papers that have already been presented to the Society, or to new matter, to which contributions are solicited. Comments on papers, brief accounts of new or original methods, and inquiries with regard to engineering problems may properly come within the scope of this department, which it is expected to make a permanent feature of The Journal.

In addition to a section devoted to technical discussion, it has further been decided by the Committee to inaugurate a section devoted to communications containing suggestions by the membership, of any kind or nature for increasing the usefulness of the Society to the community and to the individual. Brief letters for this department are also solicited in the belief that they will prove a helpful means for the guidance of the Society, in extending its activities among the membership.

## THE ANNUAL MEETING

The Annual Meeting of the Society will be held in the Engineering Societies Building in New York from December 7 to 10 and even at the present early date the prospects are that the meeting will be one of the best in the history of the Society.

The Officers and Council especially urge members not resident in New York to come to the city if possible at the time of the Annual Meeting and take part in the deliberations.

Arrangements have been completed for sessions by the Sub-Committees on Railroads, Textiles and Protection of Industrial Workers, and for papers contributed by the Committees on Machine Shop Practice and Industrial Buildings, besides unclassified papers, many of unusual interest. In addition to the professional and business sessions and the President's reception, it is planned to hold a smoker.

## REPORT OF THE NOMINATING COMMITTEE

As previously announced in The Journal, the Nominating Committee has reported the following names as candidates for the offices indicated:

*For President:*

D. S. Jacobus, New York

*For Vice-Presidents:*

Wm. B. Jackson, Chicago, Ill.
J. Sellers Bancroft, Philadelphia, Pa.
Julian Kennedy, Pittsburgh, Pa.

*For Managers:*

John H. Barr, New York
John A. Stevens, Lowell, Mass.
H. de B. Parsons, New York

*For Treasurer:*

Wm. H. Wiley, New York

## F. W. TAYLOR MEMORIAL MEETING

The Society to Promote the Science of Management issues a cordial invitation to all persons interested in scientific management and the work of the late Frederick W. Taylor to attend the special meeting to be held as a memorial to Mr. Taylor at 8.15 p. m. on Friday, October 22, in Houston Hall, University of Pennsylvania, Philadelphia, Pa. The program includes the following list of speakers several of whom were closely associated with Mr. Taylor in the vital periods of his career and important phases of his work: Rudolph Blankenburg, Mayor of Philadelphia; Carl G. Barth, Louis D. Brandeis, James M. Dodge, Edgar F. Smith, Provost of the University of Pennsylvania; Henry L. Gantt, Harlow S. Person and Sanford E. Thompson. Distinguished leaders of the scientific management movement in foreign countries have prepared appreciations which will be read.

The secretary of the society, Professor Henry W. Shelton, Hanover, N. H., will be glad to furnish information regarding this meeting to any members of the Society who desire it.

## NAVAL ADVISORY BOARD

As announced in The Journal for August, the Society was honored by an invitation from the Secretary of the Navy, the Honorable Josephus Daniels, to participate in the work of the Naval Advisory Board, recently created with Thomas A. Edison, Hon. Mem. Am. Soc. M. E., as Chairman, by the appointment of two representatives on the board. In the endeavor to select for representatives men of foresight and executive ability in combination with inventive talent, a ballot of the Council has been taken, and the members to be thus honored are as follows: William Le Roy Emmet of the General Electric Company of Schenectady, N. Y., and Spencer Miller, of the Lidgerwood Manufacturing Company of New York City and member of the Council.

Invitations were extended to eleven engineering and scientific societies to be represented on the board, as follows: The Aeronautical Society of America, the American Chemical Society, the American Electrochemical Society, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Mathematical Society, the American Society of Aeronautic Engineers, the American Society of Civil Engineers, The American Society of Mechanical Engineers, the Inventors' Guild, and the Society of Automobile Engineers. Two representatives have been chosen from each of these organizations with a view to obtaining the most advanced thought and experience in the various lines of engineering activity and scientific research.

Mr. Daniels has recently announced that the nominations of the eleven societies have been accepted, forming a board of 23 members including the chairman. The first general meeting of the board has been called for Wednesday, October 6th, at which the work will be organized and methods of procedure determined. The appointees are as follows:

Thomas A. Edison, Hon. Mem. Am. Soc. M. E., *Chairman*
Lawrence Addicks, Mem. Am. Soc. M. E.
L. H. Baekeland
Howard E. Coffin, Mem. Am. Soc. M. E.
Alfred Craven
William Le Roy Emmet, Mem. Am. Soc. M. E.
Peter Cooper Hewitt
A. M. Hunt, Mem. Am. Soc. M. E.
Benj. G. Lamme
Hudson Maxim
Spencer Miller, Mem. Am. Soc. M. E.
J. W. Richards
Andrew L. Riker, Mem. Am. Soc. M. E.
Thomas Robins
Wm. L. Saunders, Mem. Am. Soc. M. E.
Matthew B. Sellers
Elmer A. Sperry, Mem. Am. Soc. M. E.
Frank J. Sprague
Benj. B. Thayer
Arthur G. Webster
W. R. Whitney
Henry A. Wise Wood
R. S. Woodward

### WILLIAM LE ROY EMMET

William Le Roy Emmet, one of the appointees of the Society, was born at Pelham, N. Y., July 10, 1859, son of William Jenkins and Julia Colt (Pierson) Emmet. He was educated at schools in Canada, New York, and Maryland, and subsequently entered the United States Naval Academy, where he was graduated in 1881. He served as a cadet midshipman until 1883 at Annapolis and on board U. S. S. Essex, and re-entered the navy as junior lieutenant in 1898, serving as navigator on the U. S. S. Justin during the period of the Spanish war. His principal civil employment has been with the Sprague Electric Railway and Motor Company, and the General Electric Co. He has achieved fame as an electrical engineer and as an inventor, and has obtained many patents for inventions in electricity, mechanics, and thermo-dynamics, most

of which have been incidental to his undertakings as an engineer. His most important electric work has been in the development of the general use of alternating current and in the invention and design of machinery to further the practical application of alternating current, while his most important mechanical work has been in connection with the development and introduction of the steam turbine. He designed and directed the development of the Curtis turbine by the General Electric Co., every detail of which was radically new, and which was carried on with a rapidity almost unprecedented in such undertakings. He designed the machinery for the first ships driven by electric motors, and was the first serious promotor of electric ship propulsion, conducting a series of experiments with the United States collier Jupiter which are destined to be epoch-making in the history of marine transportation. He is the inventor of several types of transformers, including an air-blast type which has been extensively used; of several types of insulation of alternators, and of other details of the design of alternators which have met with general acceptance. He is the original inventor of the oil switch, a device which is now almost universally used in large electrical work. The varnished cambric cable, which is widely used, is also an Emmet invention. He is the inventor of the vertical shaft steam turbine, of which a very large number have been built, and many details of turbine design in general use are to his credit. Mr. Emmet was responsible for most of the later and most successful and largest electric work of the Niagara Falls Power Co., also for the design and introduction of the Curtis steam turbine for electric uses. His achievements have been as a pioneer of new methods rather than as an inventor, and much of his most original and most useful work could not be effectively patented nor perhaps even classified as invention. Mr. Emmet is the author of "Alternating Current Wiring and Distribution" (1894). He is a member of the American Philosophical Society, American Institute of Electrical Engineers, The American Society of Mechanical Engineers and the Society of Naval Architects and Marine Engineers. He is also a member of the University and Engineers clubs of New York, of the Mohawk Golf, the Lobique, Salmon, Adirondack League, Mohawk and Schenectady Boat Clubs. He received the degree of D.Sc. from Union College in 1910.

### SPENCER MILLER

Spencer Miller, the other appointee of the Society, was born at Waukegan, Ill., April 25, 1859, son of Samuel Fisher and Charlotte (Howe) Miller, of Worcester, Mass. He was graduated at the Worcester Polytechnic Institute in 1879, and after tutoring for a few months at Amherst College, entered the shops of the U. S. Wind Engine & Pump Co. of Batavia, Ill., where he remained for nearly a year. He then became a draftsman with the Link-Belt Machinery Co., Chicago, where he designed a number of rope drives, and a novel equipment for handling cargo by continuous systems of conveying for the Union Steamboat Company.

He made important improvements in rope driving with grooved pulleys of different diameters by varying the angle of the grooves. This invention was the subject of a paper entitled: "A Problem in Continuous Rope Driving," presented by him before the American Society of Civil Engineers in 1897. In 1886 he became associated with the Lidgerwood Manufacturing Co. of New York, which was then manufacturing a crude overhead cable system involving fall-rope carriers of the chain connected type, and he developed an entirely new fall-rope carrier system, the important part of the Lidgerwood cable-way of commerce. It was immediately adopted in various parts of the world for use in the construction of government fortifications, dams, filtration beds, sewers and similar work as in open mining. One of the stubborn engineering problems solved by Mr. Miller was the removal of cypress logs from Louisiana swamps, by means of a log-skidding cableway that reduced the cost of logs at the mill more than 50 per cent, and increased the capacity of the saw mills 400 per cent. One of the early problems of the Spanish-American war was presented to the Navy Department in the question of coaling ships at sea, and he designed a marine cableway that made it possible to tranship coal under headway at sea. In coaling ships in harbor his method of broadside handling has increased the capacity from 25 to 150 tons per hour, and one man now does the work which under the old system required eighty. Many new colliers of the U. S. Navy, notably the Jason, Orion and Neptune, are equipped with this transfer system, for delivering coal to ships alongside in smooth water. In 1914 he made the refueling of warships at sea the subject of a paper read before the Society of Naval Architects and Marine Engineers. One of the most revolutionary devices invented by Mr. Miller is his breeches buoy cableway apparatus in use by the U. S. revenue cutter service, by which passengers can be rescued from any ship in the heaviest sea.

Aside from his engineering activities, Mr. Miller is greatly interested in civic and municipal improvement, especially in the establishment of public libraries, parks and playgrounds in his home city, South Orange, N. J. He is a director of the South Orange Free Public Library and past president of the Playground Commission of South Orange. He is vice-president of the Essex County Mosquito Extermination Commission of New Jersey, and is the author of a paper entitled "Prevention of Mosquito Breeding," read before the American Society of Civil Engineers in 1912. He is a manager of The American Society of Mechanical Engineers; member of the American Society of Civil En-

gineers, American Institute of Mining Engineers, Society of Naval Architects and Marine Engineers, and the Canadian Institute of Mining Engineers. He is also a member of the Engineers Club, New York; Essex County Country Club, Orange, and the Metropolitan Club and University Club of Washington.

The representatives chosen from the other societies are as follows:

*Aeronautical Society of America:* Matthew Bacon Sellers of Baltimore, Md., and Hudson Maxim of Brooklyn, N. Y. Mr. Sellers is a graduate of the Lawrence Scientific School and is at present director of the Technical Board of the Aeronautical Society of America. He was the first to determine dynamic wind pressure on arched surfaces by means of "wind funnel." Mr. Maxim is an ordnance and explosive expert and maker of the first smokeless powder adopted by the United States Government.

*American Chemical Society:* W. R. Whitney of Schenectady, N. Y., and L. H. Baekeland of Yonkers, N. Y. Mr. Whitney is a graduate of Massachusetts Institute of Technology, '90. He is at present director of the Research Laboratory of the General Electric Company where he has been the moving spirit in the perfection of metallic electric lamp filaments and the development of wrought tungsten. Mr. Baekeland is a graduate of the University of Ghent, '82. He was the founder of the Nepera Chemical Company and inventor of photographic paper and bakelite. He is at present in private practice.

*American Electrochemical Society:* Joseph Williams Richards, of South Bethlehem, Pa., and Lawrence Addicks of Chrome, N. J. Mr. Richards is professor of electro chemistry at Lehigh University and is the author of numerous works on electro metallurgy. Mr. Addicks is a graduate of the Massachusetts Institute of Technology, '89, and a member of the Am. Soc. M. E. At the present time, he is consulting engineer for Phelps, Dodge & Co. and is an authority on the metallurgy of copper.

*American Institute of Electrical Engineers:* Frank J. Sprague of New York City and B. G. Lamme of Pittsburgh, Pa. Mr. Sprague is a graduate of the Naval Academy, '88, and now is consulting engineer for the Sprague, Otis and General Electric Companies. He was the founder of the Sprague Electric Railway Motor Company and was concerned in establishing the first electric trolley systems in the United States. Mr. Lamme is a graduate of the Ohio State University, '88, and is now chief engineer of the Westinghouse Electric and Manufacturing Company and a prolific inventor.

*American Institute of Mining Engineers:* William L. Saunders and Benjamin B. Thayer of New York City. Mr. Saunders is a graduate of the University of Pennsylvania, '86, and a member of the Am. Soc. M. E. He is chairman of the board of directors of the Ingersoll-Rand Company and inventor of many devices for subaqueous and rock drilling. Mr. Thayer is a graduate of Harvard University, '85. He is president of the Anaconda Copper Mining Company and an authority on explosives.

*American Mathematical Society:* Robert S. Woodward of Washington, D. C., and Arthur G. Webster of Worcester, Mass. Mr. Woodward is a graduate of the University of Michigan, '72. He is the president of the Carnegie Institution and an authority on astronomy, geography and mathematical physics. Mr. Webster is a graduate of Harvard, '85, and is a professor at Clark University. He is an authority on sound, its production and measurement.

*American Society of Aeronautic Engineers:* Henry A. Wise Wood and Elmer A. Sperry of New York City. Mr. Wood is engineer and manufacturer of printing machinery and student of aeronautics. Mr. Sperry is a graduate of Cornell, '76, and Mem. Am. Soc. M. E. He is the founder of the Sperry Electric Company and designer of electric appliances and gyroscopic stabilizer for ships and aeroplanes and the gyrocompass.

*American Society of Civil Engineers:* A. M. Hunt and Alfred Craven, both of New York City. Mr. Hunt is a graduate of the Naval Academy, '79, and a Mem. Am. Soc. M. E. He is a consulting engineer experienced in the development of hydroelectric, steam and gas plants. Mr. Craven is also a graduate of the Naval Academy, '67. He is chief engineer of the Public Service Commission and was formerly Division Engineer in charge of the construction work on the Croton Aqueduct and reservoirs.

*Inventors' Guild:* Peter C. Hewitt of New York City and Thomas Robins of Stamford, Conn. Mr. Hewitt is an inventor of electric lamp appliances to enable direct current apparatus to be used with alternating current circuits, and devices for telephones and aircraft. Mr. Robins is a graduate of Princeton. He is now president of the Robins Conveying Belt Company and inventor of many devices for conveying coal and ore.

*Society of Automobile Engineers:* Andrew L. Riker of Detroit, Mich., and Howard E. Coffin of Detroit, Mich. Both Mr. Coffin and Mr. Riker are members of the Society and past presidents of the Society of Automobile Engineers. Mr. Coffin is a graduate of the University of Michigan, '96. He is now vice-president of the Hudson Motor Car Company and active in the development of internal combustion engines. Mr. Riker is vice-president of the Locomobile Company. He is an electrical and mechanical engineer and inventor of many automobile devices.

## YALE ENGINEERING ASSOCIATION

An organization has recently been formed among graduates from Yale University, to be known as Yale Engineering Association. Its purpose is to serve in an advisory capacity the engineering departments

of the University, to make recommendations regarding the courses, to furnish speakers on engineering topics for the undergraduates, to help young graduates in securing positions, to attack the problem of engineering education and to encourage Yale men to become affiliated with national societies. The executive committee has Edwin M. Herr, Mem. Am. Soc. M. E., as President, Harry N. Covell, Mem. Am. Soc. M. E., as Vice-President, and Richard T. Dana as Secretary-Treasurer. The first meeting of the association will be held in New Haven in the early part of November.

## REPORT ON THE RESERVE CORPS OF CIVILIAN ENGINEERS

The suggestion was made last spring that the national engineering societies offer to assist the U. S. War Department in the formation of an engineer reserve in the United States Army. When brought to the attention of some of the officers of the Army, the suggestion was commended and they confirmed the belief that the need of such a reserve was a real one. The European War has distinctly shown that in time of war engineers of varied experience are required on a scale never before realized. In our own army no adequate provision is made for great numbers of engineers, for although the regular corps of engineers is composed of men of the very highest professional proficiency in certain lines, it is far short of the numerical strength that would be immediately required.

Acting on the suggestion for an engineer reserve, the American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Institute of Consulting Engineers appointed committees authorized and directed to take such steps as might be advisable to urge the organization of such a reserve corps as part of the regular army, and so assist in putting the United States in a better condition of preparedness against war. Conferences were held with the Secretary of War and the officers of the General Staff and of the War College, and so much encouragement was received that it was felt advisable to form a single committee to represent jointly the five societies—in short, the engineering profession as a whole. This will simplify future conferences with those in authority and show that the various engineering organizations are earnestly coöperating.

After obtaining formal permission from the five societies, a joint committee has now been formed, consisting of the chairmen of the previously appointed society committees, as follows:

Wm. Barclay Parsons, *chairman Committee, American Society of Civil Engineers,*

Henry S. Drinker, *chairman Committee, American Institute of Mining Engineers,*

William H. Wiley, *chairman Committee, American Society of Mechanical Engineers,*

Bion J. Arnold, *chairman Committee, American Institute of Electrical Engineers,*

Ralph D. Mershon, *chairman Committee, American Institute of Consulting Engineers.*

This committee has selected Mr. Parsons as chairman and is in communication with the War Department.

Before a reserve corps can be formed, legislation authorizing it must be passed by Congress and approved by the President. The details of such legislation are now being studied by the War Department. While no decision has been reached, it is under consideration to issue commissions as officers to such engineers as will meet certain professional and physical standards. These officers would, in times of necessity, be subject to orders from the Secretary of War as officers of the army, and at other times they would perform such duty as would not seriously interfere with their ordinary work, but would give each officer some military education and experience. In this way it is hoped to have a large body of engineers which could be called quickly to duty.

The separate committees are still in existence to do the necessary work among their fellow members of the several societies as soon as the decision of the War Department is given and a general scheme of organization is adopted.

Wm. Barclay Parsons, *Chairman,*
Henry S. Drinker,
William H. Wiley,
Bion J. Arnold,
Ralph D. Mershon.
*Joint Committee of the National Engineering Societies on the National Reserve Corps of Engineers.*

August 28, 1915.

## INTERNATIONAL GAS CONGRESS

The International Gas Congress, under the auspices of the American Gas Institute, was held in San Francisco during the week of September 27th. The Congress opened with the annual meeting of the Pacific Coast Gas Association and a reception to the President of the American Gas Institute, Dr. Alex C. Humphreys, Mem. Am. Soc. M. E. The following day the professional sessions of the Congress were commenced and the annual meeting of the American Gas Institute took place. Symposiums on illumination, commercial aspects of the gas business and modern coal gas processes and of present British practices in the manufacture of coal gas were held during the week. President C. C. Moore of the Panama-Pacific International Exposition presented the Congress with a bronze medal. A number of entertainment features were provided and a visit was paid to the gas exhibits at the Exposition. The Congress closes on October 2.

# APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON NOVEMBER 10, 1915

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages would qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior Grade only. Applications for change of grading are also posted.

*The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned.* All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received by November 10, 1915.

## NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ALEXANDER, JOHN S., Dist. Mgr., Diamond Pwr. Specialty Co., Philadelphia., Pa.

ANDERSON, ANDREW F., Instructor in Shopwork, Schools of the City of New York.

BEAGHEN, THOMAS, JR., Master Car Builder, Union Tank Line Co., New York.

BIGGERT, FLORENCE C., JR., Ch. Engr., United Engrg. & Fdy. Co., Pittsburgh, Pa.

BRIDGES, LUTHER W., Mech. Engr., with Chas. H. Tenney & Co., Boston, Mass.

BUERGER, CHARLES B., Cons. Engr., Atlantic Refining Co., Philadelphia, Pa.

CANDA, CHARLES A., Secy., Chrome Steel Wks., Chrome, N. J.

CHATILLON, RALPH F., Vice-Pres., John Chatillon & Sons, New York.

CLARK, ALBERT B., Efficiency Engr., Commonwealth Edison Co., Chicago, Ill.

DAWSON, GEORGE H., Engr.-in-charge of Equip., Remington Arms & Ammunition Co., Ilion, N. Y.

DISSEL, THEODORE A., Mgr., Cameron Appliance Co., Everett, Mass.

EDMONDSON, RALPH S., Engr., Amer. Abrasive Metals Co., New York.

EGLIN, WILLIAM C. L., 2nd Vice-Pres., and Ch. Engr., The Philadelphia Elec. Co., Philadelphia, Pa.

ENKE, GEORGE P., Insurance Engr., Goffe & Little, New York.

FEELEY, FRANK G., Mgr., Chicago Branch, M. D. Knowlton Co., Chicago, Ill.

FELL, HUGH P., Mech. Div. Ch., Elec. Bond & Share Co., New York.

FENN, ROBERT H., Engr. and Pur. Agt., Kent Mill Co., Brooklyn, N. Y.

FERGUSON, HUGH M., Mech. Engr., Missoula Light & Water Co., Missoula, Mont.

FRALICH, JOHN S. Y., Asst. Res. Engr., The Westinghouse Air Brake Co., Chicago, Ill.

GALE, WALTER L., Engr. and Tool Designer, Hopkins & Allen Arms Co., Norwich, Conn.

GENTLES, FRANK, formerly Ch. Engr., Cathedral Corp., Garden City, L. I., N. Y.

GILLIAM, THOMAS B., Engr. of Tests, Island Creek Coal Sales Co., Cincinnati, Ohio.

HATFIELD, ROBERT L., Prop., Hatfield & Co., Newark, N. J.

HENDRY, WILLIAM S., Instructor in Mech. Arts, Univ. of Arizona, Tucson, Ariz.

HERR, BENJAMIN M., Combus. Engr., Stoker Dept., The Westinghouse Elec. & Mfg. Co., Chicago, Ill.

HOBSON, RUSSELL B., Inventor, New Brighton, N. Y.

HULL, JOHN D., Private business, engaged in mechanical construction, Seattle, Wash.

HUNT, HARRY V., Supt., The Hooven, Owens, Rentschler Co., Hamilton, Ohio.

JEGGE, EMIL G., Mech. Engr., Arlington Co., Arlington, N. J.

JERAULD, WILLIAM E., Genl. Supt., Amer. Steam Gauge & Valve Mfg. Co., Boston, Mass.

JOHNSON, JOSIAH F., Asst. Engr., Turbine Dept., The Westinghouse Mch. Co., E. Pittsburgh, Pa.

JONES, RICHARD E., Supt. Automatic Feeding Mch. Dept., Dexter Folder Co., Pearl River, N. Y.

KISTNER, HERMAN, Prod. Engr., Otis Elev. Co., Harrison, N. J.

KLOCK, ERNEST L., Supt., New Niguero Sugar Co., New York.

KOCH, FELIX, Mech. Engr., Pressed Steel Car Co., Pittsburgh, Pa.

LAUBENSTEIN, A. R., Mgr. and Treas., Laubenstein Mfg. Co., Ashland, Pa.

LUND, HUGO, Ch. Draftsman, Metropolitan Street Rwy. Co., Kansas City, Mo.

LYND, ROY E., Asst. Supt., Richardson & Boynton Co., Dover, N. J.

MCCALLUM, JAMES R., Designer, The Crown Cork & Seal Co., New York.

MERRICK, DWIGHT V., Cons. Engr., New York.

MERRITT, LOUIS G., Pres., Merritt Mfg. Co., Lockport, N. Y.

MICHAELIS, GEORGE V. S., Secy., Bell Products Co., Springfield, Mass.

MITTENDORF, WILLIAM, Asst. Ch. Engr., The Cincinnati Traction Co., Cincinnati, Ohio.

MURRAY, WILLIAM E., Ch. of Steam Boiler Insp. Dept., City of Seattle, Wash.

NEEFUS, HAROLD V. H., Mech. Engr., The Texas Company, New York.

NOLAN, M. WILLIAM, Mech. Engr., Dept. of Steam Engrg., Cambria Steel Co., Johnstown, Pa.

PERSONS, J. O., Asst. Shop Supt. and Mine Prod. Expert, Navy Yard, Norfolk, Va.

PRICE, JOHN B., Engr. in Charge of Motor Dept., Ilg Elec. Ventilating Co., Chicago, Ill.

Quinlivan, Oswald, Mech. Engr., U. S. Engr. Office, Albany, N. Y.

Raymond, Cyrus F., Indus. Engr., The B. F. Goodrich Co., Akron, Ohio.

Reid, Arthur, Commr. of Pub. Utilities, Corp. of City of Lethbridge, Alberta, Canada.

Schleyer, Victor, Designing Engr., American Well Wks., Aurora, Ill.

Scovell, Clinton H., Indus. Engr., Clinton H. Scovell & Co., Boston, Mass.

Smith, Abram E., Asst. Master Car Builder, Union Tank Line Co., New York.

Tryon, Clarence A., Engr., Internatl. Acheson Graphite Co., Niagara Falls, N. Y.

Walker, Lee E., with Good Roads Mchy. Co., Philadelphia, Pa.

Walther, Arthur C., Engr. and Supt. of Constr., Nixon Nitration Wks., New Brunswick, N. J.

Wilson, Amyuit L., Boiler House Efficiency Engr., Spreckles Sugar Refining Co., Philadelphia, Pa.

Wilson, Jonathan A., Traveling Engr., Babcock & Wilcox Co., Bayonne, N. J.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Barker, Ernest S., Engr.-in-charge, Chas. H. Scammell Co., Factory, West New York, N. J.

Bingaman, Ralph W., Engr., Communipaw Steel Co., New York.

Brady, George S., Efficiency Engr., Winchester Repeating Arms Co., New Haven, Conn.

Brennan, Edward M., Junior Mech. Engr., Div. of Valuation, Interstate Commerce Comm., Chattanooga, Tenn.

Cady, Harrison R., Asst. Mech. Engr., Bureau of Water Supply, Philadelphia, Pa.

Goodspeed, Charles B., Vice-Pres., The Buckeye Steel Castings Co., Chicago, Ill.

Keller, George M., Prod. Supvr., General Motors Truck Co., Pontiac, Mich.

Kiefer, Paul J., Instr. in Mech. Engrg., Univ. of Penn., Philadelphia, Pa.

Knapp, Walter, Shop Supt., Lea-Courtney Co., Newark, N. J.

Lewis, Goodrich Q., Mech. Engr., as Asst. to Mech. Supt., with W. H. Miner, Chicago, Ill.

McCurdy, Alexander D., Partner, McCurdy & Boyer, Philadelphia, Pa.

McLaren, Lewis L., Steam Engr., Wisconsin Steel Co., So. Chicago, Ill.

Morse, Walter R., Asst. Supt., The Shoe Hardware Co., Waterbury, Conn.

Nelson, John E., Draftsman, De Laval Separator Co., Poughkeepsie, N. Y.

Perham, Deane E., with The Automatic Refrigerating Co., Hartford, Conn.

Powell, Paul R., Designing Draftsman, The Crown Cork & Seal Co., Baltimore, Md.

Riedl, Albert F., Efficiency Engr., Gender, Paeschke & Frey Co., Milwaukee, Wis.

Sticksel, C. P., Mech. Engr. or Mas. Mech., The Globe Soap Co., St. Bernard, Ohio.

Tyson, James S. Y., Engr., Mexican Petroleum Corp., Carteret, N. J.

Walsh, Frank J., Mech. Expert, Galena-Signal Oil Co., Chicago, Ill.

Welch, James B., Asst. Shop Supt., Indus. Dept., United States Navy Yard, Norfolk, Va.

FOR CONSIDERATION AS JUNIOR

Adams, Carroll E., Draftsman, Jenks & Ballou, Cons. Engrs., Providence, R. I.

Barnaby, Ralph S., Insptr. of Material, The Elco Co., Bayonne, N. J.

Bodenstein, William E., Mech. Engr., Stegner & Hughes, Arch. & Engrs., Newport, Ky.

Comfort, Newman, Mgr., Univ. Inspection Co. of Ia., Nebr. Div., Omaha, Neb.

Dickson, Charles H., Jr., Engrg. Dept., Natl. Sugar Refining Co. of N. J., Long Island City, N. Y.

Freeman, Benjamin W., Mgr., The Benjamin W. Freeman Co., St. Louis, Mo.

Gest, Alex. P., Jr., Mech. Engr., Chem. Dept., Barrett Mfg. Co., Philadelphia, Pa.

Hill, Francis L., Draftsman, Covington Mch. Co., Covington, Va.

Hoffmann, John E., Mech. Engr., Testing Dept., Pencoyd Iron Wks., Amer. Bridge Co., Pencoyd, Pa.

Kehl, Robert J., Junior Engr., Oxweld Acetylene Co., Chicago, Ill.

Lacazette, Alfred A., Engrg., West India Oil Co., New York.

Mathewson, James S., Instr. in Engrg., Univ. of Akron, Akron, Ohio.

Maynz, Theodore, Engr., Combustion Engrg. Corp., New York.

Neagle, Russell J., with Boston Edison Elec. Ill. Co., Boston, Mass.

Palmer, Brian C., Mech. Engr., Amer. Taximeter Co., New York.

Pratt, Lewis W., Safety Inspector, Aetna Life Ins. Co., Bureau of Insp. and Accident Prevention, Hartford, Conn.

Priebe, Ernest B., Erecting Engr., Amer. Engrg. Co., Philadelphia, Pa.

Sausen, Bert R., Mech. Engr., Schutte & Koerting Co., Philadelphia, Pa.

Savedoff, Morris M., Insp. Dept., New England Westinghouse Co., Chicopee Falls, Mass.

Vine, Howard L., Mech. Draftsman, The Reeves Bros. Co., Alliance, Ohio.

Wallner, Edward P., with Nordyke & Marmon Co., Indianapolis, Ind.

Zabriskie, William H., Standard Oil Co. of New York, Long Island City, N. Y.

Zugelter, George E., Engrg. Dept., The Lunkenheimer Co., Cincinnati, Ohio.

## APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

Coutant, Jay G., Engr., Railway Materials Co., Chicago, Ill.

PROMOTION FROM JUNIOR

Blake, Raymond P., Efficiency Engr., Dodge Bros., Detroit, Mich.

Jennings, Irving C., Vice-Pres., Nash Engrg. Co., So. Norwalk, Conn.

Murphy, Thomas R. H., Indus. Engr., Jos. H. Wallace & Co., New York.

Rickcord, Reginald V., Instr., Dept. of Public Instruction, Rochester, N. Y.

Symonds, Nathaniel G., Mgr. Prime Mover Div., Westinghouse Elec. & Mfg. Co., Chicago, Ill.

Tuttle, Irving E., Pwr. Plant Engr., Baker, Smith & Co., New York.

## SUMMARY

| | |
|---|---|
| New applications | 103 |
| Applications for change of grading: | |
| Promotion from Associate-Member | 1 |
| Promotion from Junior | 6 |
| | 110 |

# SAN FRANCISCO MEETING

*THE Panama-Pacific International Exposition, held this year at San Francisco, and the notable engineering event exemplified in the International Engineering Congress, were the occasion of the special meeting of the Society on September 16 and 17, which is the first mid-year meeting held by the Society since the early years of its organization. Advantage was taken of this unusual opportunity to deal with subjects of local interest. Two of the papers were devoted to engineering at the Exposition and two others to the oil engine in relation to power production on the Pacific slope. A fifth paper dealt with an investigation upon the Strength of Gear Teeth made at Leland Stanford Junior University, California. The two papers upon the Exposition are published in this issue practically in full, while the remaining three will be given in the next number of The Journal.*

## ENGINEERING FEATURES OF THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION

BY GUY L. BAYLEY, SAN FRANCISCO, CAL.

Member of the Society

An exposition is a modern city built to order and as such must be provided with every utility and convenience with which the public is familiar. Even though the existence of the exposition be short, none of these may be omitted or restricted. In the planning and construction of such a project all branches of engineering play a part and, while there are many details which require special treatment, the real engineering problem lies in the modifying of standard practice to secure the temporary service desired at the lowest possible cost, with the use of such material as will facilitate the final dismantling of the exposition and the realization of a high salvage value.

*The organization of the engineering departments of the Panama-Pacific International Exposition, the layout of the grounds, the design and construction of the buildings, and the operation of the service facilities have proven an engineering undertaking of the greatest magnitude. Mr. Bayley has pointed out in his paper many unusual features of the great undertaking which will be of absorbing interest to engineers. Attention is called to the extensive use of timber construction for the buildings, which introduced unusual constructive problems. The provisions for power, water supply, fire protection, sanitation, etc., are discussed in considerable detail, and further information upon these important features is to be filed by the author in the Library of the United Engineering Society for permanent reference.*

### HYDRAULIC FILLS

At the time the Exposition took possession of its site, that portion of the grounds to be occupied by the main buildings (about 70 acres) was under 12 ft. of water at mean high tide, and it was necessary to fill this section and, in addition, the low lands within the Presidio (a U. S. Military reesrvation). The filling was done by suction dredges which operated off-shore a distance of about 300 ft. in depths of from 30 to 50 ft. The discharge carried 8 per cent to 10 per cent of solid matter which ran 60 per cent to 70 per cent sand, the balance being sea mud and silt. The dredged material was handled so that it displaced about 5 ft. of soft ooze which existed in the bottom of the basin, the ooze being dissolved and carried out through the waste gates. In order to expedite the work of removing the soft portions of the original bottom, water instead of a mixture was pumped at intervals. To reclaim this portion of the site required the pumping of 1,300,000 cu. yd. of material at a cost of $218,000.

Shortly after the fill had been completed, settlement stakes were driven and readings taken to establish the rate of settlement, which was rapid at the start and decreased shortly to a slow but uniform rate. After the initial settlement had taken place borings were made at the sites of all buildings of the main group to determine the character of the underlying material and depth of hardpan. Test piles were driven to ascertain the supporting value of the ground at various depths. These tests showed that the dredger fill not only had no supporting value, but actually produced a load on the piles driven through it, tending to drag the piles down at the speed of its own settlement. As the result of a large number of tests, it was decided not to depend upon the thin strata of blue mud and clay underlying the dredger fill, but to drive the piles to a penetration of 1 in. to the blow of a No. 1 Vulcan steam hammer in the hard layer of green sand and clay overlying the hardpan.

In the areas not affected by the dredger fill, there was a layer of overlying soft clay, and tests showed that short piles terminating in the sand offered practically as much resistance as those driven through the sand into the clay. The sand had a supporting value of 3000 lb. per sq. ft. and spread footings were considered, but it was found that short piles averaging 14 ft. provided a cheaper and simpler construction. It was also thought that the adoption of pile footings would offer greater resistance in case of earthquake, previous experience having indicated that structures were most affected when resting on filled ground by means of spread footings.

The decision not to drive into the substratum of soft clay resulted in a great saving. The results of these tests were of

Presented at the Panama-Pacific International Exposition Meeting of the Society, San Francisco, September 1915. The paper may be obtained in pamphlet form; 25 cents to members, 50 cents to non-members.

the greatest value as they provided definite data for the design of foundations. The information gained was furnished to bidders and naturally resulted in lower prices, as contractors were able to know the lengths of piling required and thus avoid unnecessary waste. The total number of piles driven was 15,654 and the linear feet 645,692. The average cost was $24\frac{1}{2}$ cents per lin. ft. below cut-off, and the average length of pile 41.2 ft.

The dredger fill in the Presidio was shallow, not exceeding 6 ft. at any point. The total amount pumped was 400,000 cu. yd. which reclaimed 114 acres of land at a cost of $84,000. The buildings in this area are light frame structures and as a rule rest on spread footings.

### STRUCTURAL DESIGN

With the exception of the frames of the Tower of Jewels and the Palace of Fine Arts and the dome of the Palace of Horticulture, the buildings are timber structures. All the buildings, except Festival Hall, have pile foundations for the framework. The floor sub-structures of those buildings located on the dredger fill have pile foundations and the others spread footings or mud sills, depending upon the nature of the ground. The pile foundations for the Tower of Jewels are capped with reinforced concrete. Prior to the decision on the type of foundations to be used in each instance, tests were made of the ground on which the buildings were to be erected. These tests gave accurate data as to the length of piles required and the allowable loading. The piles varied from 13 to 75 ft. in length, although a few 120 ft. long were required under the Transportation Building. The safe carrying capacity of one pile was found to be 20 tons.

From an engineering viewpoint, the Tower of Jewels is probably the most interesting structure on the grounds. It is 435 ft. high and 120 ft. square in plan from the ground level to elevation 152 ft., from which level to elevation 335 ft. it takes the form of a truncated pyramid. From elevation 335 ft. to 364 ft., the frame is made up of four vertical columns 20 ft. apart and braced with rods. Above this elevation the frame forms a tower 8 ft. by 8 ft. in plan to elevation 397 ft., from which point runs a central post which supports a ball 17 ft. in diameter. The framing of the tower required 1403 tons of structural steel.

The glass dome of the Palace of Horticulture has an extreme height of 185 ft. and is 152 ft. in diameter. The upper portion has the form of a half sphere, while the lower portion is cylindrical. The supporting frame of the dome was figured as a true dome and consists of 24 steel ribs tied together by 11 horizontal rings. The dome and cylinder are carried on plate girders and trusses which in turn are supported by 8 structural piers 65 ft. in height.

The framing of the dome of Festival Hall presented many difficulties, owing to the size of the dome and the large arched openings on two sides. The curved dome was built on a supporting pyramidal dome 140 ft. in diameter with 16 trussed ribs. This dome was carried by 4 main piers and by 8 columns. The ribs occurring over the arched openings were carried by two trusses of 77-ft. span. The pyramidal dome was designed as a true dome, the ring tension at the supports being cared for by two $3\frac{1}{8}$-in. rods. The dome roof with a diameter of 172 ft. was built of sheathing supported by 2-in. by 6-in. rafters resting on studded walls which were carried by beams spanning the main ribs. The exterior ceiling was suspended from the dome ribs.

Fig. 1 Panama-Pacific International Exposition, 1915

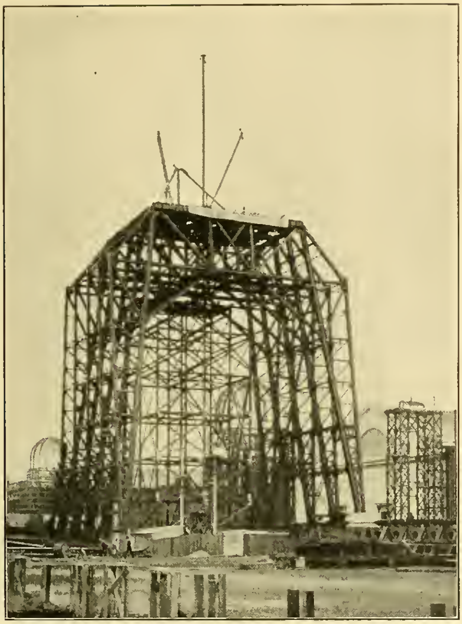

Fig. 2 Steel Frame of Tower of Jewels to Elevation 152 Ft.

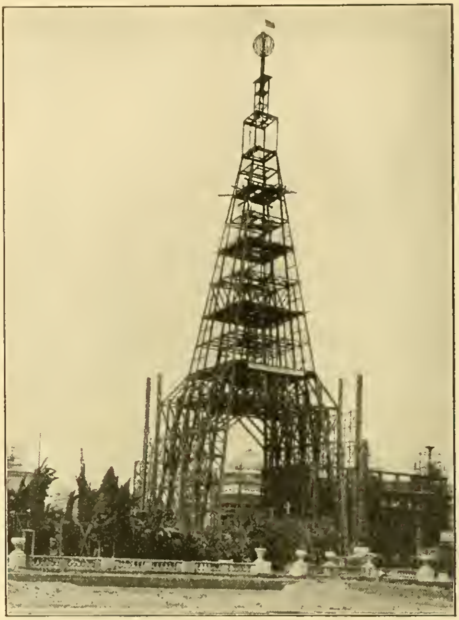

Fig. 3 Completed Steel Frame, Tower of Jewels

Fig. 4 Timber Frame over Steel Frame, Tower of Jewels

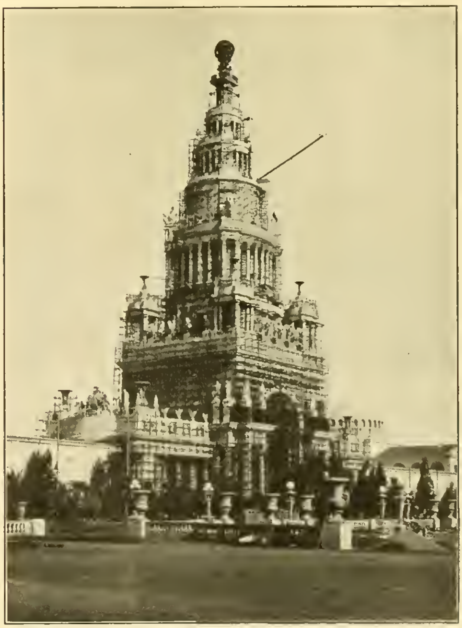

Fig. 5 Tower of Jewels, Plaster Work Being Applied

For a frame structure the Palace of Machinery claims attention on account of its size—968 ft. by 368 ft., with a height of 136 ft. in the transverse bays and 120 ft. in the longitudinal bays. The spans of the longitudinal and transverse bays are 75 ft. The arched trusses give the building an attractive appearance and the framing is of interest, particularly at the intersections of the longitudinal and transverse bays. The columns of the longitudinal bays were designed to support traveling cranes carrying loads up to 30 tons.

Owing to fire protection requirements, the frame of the Palace of Fine Arts was built of steel. The building is curved in plan, 950 ft. long and 135 ft. wide. Three hinged arches were used for this building, the span being 131 ft. and the height from the floor to the center hinge 48 ft. Steel channels placed beneath the floor served as ties for the lower hinges. Light bracing trusses were used to connect the arches and form supports for the purlins. The roof and walls were constructed with cement-plaster on metal fabric, the roof with a thickness of 3 in. and the walls $2\frac{1}{2}$ in.

The Auditorium, located in the Civic Center, was built at an expense of over $1,000,000, and is a permanent fireproof structure of four stories, occupying a city block 200 ft. by 187 ft. The main hall has a seating capacity of 10,650, and there are 10 halls or large rooms for conventions. Flanking the main hall on each side and extending the height of two stories are banquet rooms, 56 ft. by 136 ft. The only feature of the building that is unusual is the dome, which may be described as a truncated octagonal pyramid with a maximum diameter of 205 ft. 6 in. and a height of 40 ft. The height of the spring line of the dome from the floor is 79 ft. The dome framework is of interest, not only on account of its great diameter, but also from the fact that it was designed as a true dome. The eight main trussed-ribs are 6 ft. deep at the upper end and 10 ft. at the lower, and are carried by eight columns. The horizontal thrust at the bottom is taken up by four $1\frac{7}{8}$-in. by 6-in. eyebars. The supporting columns are connected by trusses having a depth of 14 ft.

There are no unusual features in the structural design of the eight buildings which form the main group, although the framing of the domes and half domes were interesting problems on account of the use of timber where steel would have been used in ordinary practice. The domes are 100 ft. in diameter and 162 ft. high, each with 32 ribs resting on a circular girder which in turn is supported by four girders with connecting diagonals at the corners, thus providing eight points of support for the ring. Half domes, 112 ft. high and 72 ft. wide, form the entrances to the Palaces of Food Products and Education and are constructed of double, 3-hinged timber arches for carrying the walls and arched roof, and a steel 3-hinged arch for carrying the trussed ribs. The construction of the walls is quite different from that employed at previous expositions in that a single line of 2-in. by 6-in. studs, 18-in. centers, are used with horizontal girders every 13 ft., instead of the usual double line of studs laced together. The floors in these buildings, as elsewhere, are constructed of 2-in. shiplap. Where spread footings were used, the floor was laid on 2-in. by 8-in. joists, 2-ft. centers with 9-ft. spans, supported by 6-in. by 8-in. girders with 9-ft. spans, while with pile footings 2-in. by 12-in. joists are used 2-ft. centers, 14-ft. spans, with 10-in. by 16-in. girders, 20-ft. spans.

The brevity with which this phase of the work has been treated is no index to its importance, as the making of the structural designs formed a large part of the engineering work. Necessarily, once the elements of a design had been worked out, there was much duplication, but a great deal of skill and originality were shown in applying to timber framing much of the knowledge which has been acquired in recent years relative to steel frame structures.

At the start rules were made governing all structural work in which the allowable loads, stresses and other designing data were established, with the result that the designs were consistent throughout. Some idea of the volume of work handled by the structural bureau may be gained from the number of drawings made, there being 781 sheets covering an area of 13,277 sq. ft., from which 27,355 prints were made. When the work was at its height 70 structural draftsmen were employed by the structural bureau.

### SEWER SYSTEM

Use was made of a number of city sewers which crossed the site, one of which was large enough to be used as the main outfall for all sanitary sewage. A separate system was installed for storm water, with frequent connections to the Bay. The plan of using separate sewers was adopted as it was permissible to place the storm sewer near the surface and use a cheap form of construction. The amount of storm water to be cared for was figured from the San Francisco rainfall rate curve, which gives a rate of 2.16 in. per hour for a 5-min. interval and a rate of 0.598 in. for a 60-min. interval. The handling of the sanitary sewage in the low area within the Presidio necessitated a pumping plant, which was located near the center of the district and discharged into the main outfall through 1170 ft. of 20-in. wood stave pipe.

The sewer system was simple and direct and was based on the use of second quality vitrified pipe in sizes from 8-in. to 15-in. and banded wood stave pipe for sizes up to 30-in., except that in the States and Foreign sites, where water-tightness was a requirement, wood stave pipe as small as 10-in. was used. The sewer system, including catch basins, cost $142,000, and comprised some 28 miles of pipe.

### TRANSPORTATION

The handling of building material and exhibits proved to be one of the largest tasks in the construction of the Exposition.

Owing to the location of the Exposition along the shore of the Bay of San Francisco, it was possible to unload the lumber, which formed the bulk of the material to be handled, direct from vessels to the Exposition's wharves. The principal problem was to get the lumber away from the wharves which provided little or no storage, and the plan adopted was to use 2-wheeled lumber trucks, upon which the lumber was landed by ship's tackle. Single horses were used to drag the trucks, the driver guiding the truck by hand.

The unloading rate per vessel reached 30,000 ft. per hour at times, and to care for this quantity of lumber required some 200 trucks, 68 horses and 140 men.

Plank roads were laid around the four sides of each building site and over these the lumber was hauled to the adjacent storage space. The lumber was so ordered that an entire cargo would be for one designated building, and there was, therefore, no necessity for sorting on the wharf. The work of receiving, hauling and rough-piling the lumber was let to

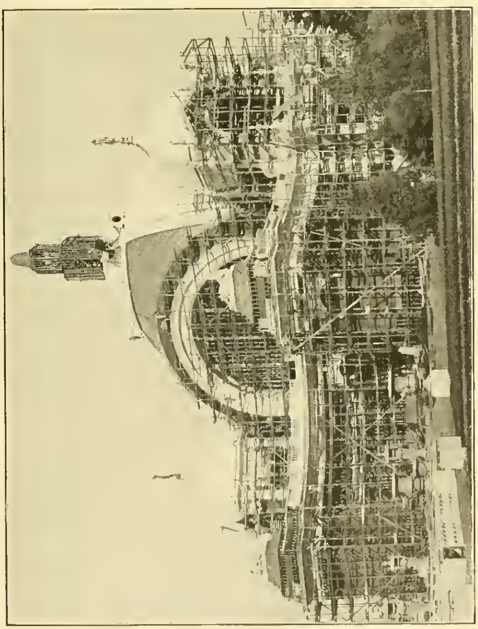

Fig. 6 Festival Hall Partially Completed

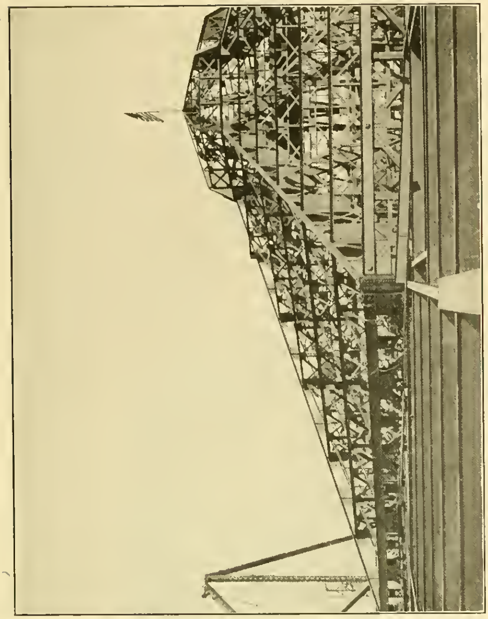

Fig. 7 Dome of Auditorium

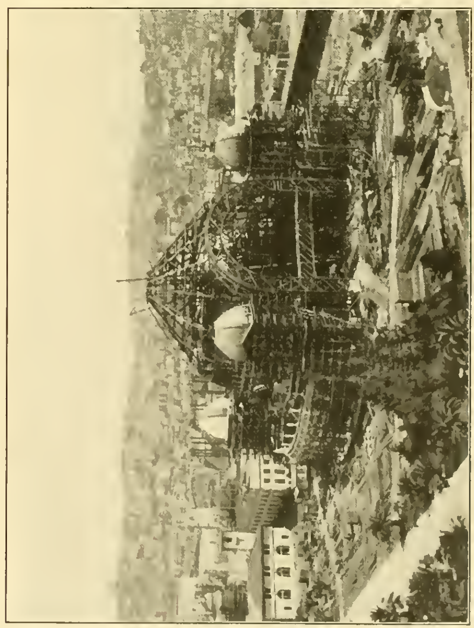

Fig. 8 Dome and Arched Opening, Festival Hall

Fig. 9 Completed Dome of Palace of Horticulture

contract at prices varying from 35 cents per 1000 ft. for short hauls to $1.10 per 1000 ft. for long hauls. The total amount of lumber handled under contract was 68,131,000 ft. and the amount paid to the contractor for this work was $68,000. The plank roads referred to consisted of 3-in. planks 16 ft. long laid on 3-in. sills, and were laid by the Exposition's forces, approximately 1,950,000 ft. of lumber being used for this purpose alone.

In addition to the amount of lumber unloaded by contract there was handled over the wharves, in the manner described, about 9,500,000 ft. of lumber. The balance of the lumber used by the Exposition and its participants was purchased locally and delivered by teams and wagons, and amounted to about 32,000,000 ft.

Building materials other than lumber have been estimated as being about 800,000 tons. To handle these enormous quantities of materials expeditiously and without confusion required careful planning of temporary roadways and the systematic routing of traffic.

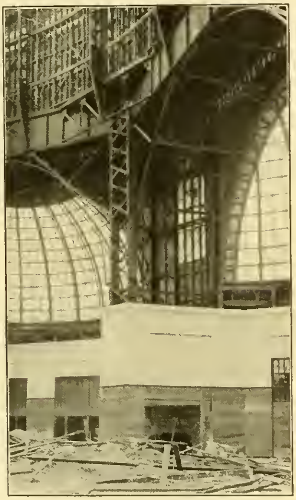

Fig. 10 Connection of Piles to Girders, Palace of Horticulture Dome

The Exposition Terminal Railway was built primarily for handling exhibits, but was used to advantage during the construction period for distributing 36,000 tons of construction material and 5,000 tons of general freight received on cars. This road was built by the Exposition's forces and included 11½ miles of standard track, 3½ miles of which was laid within the exhibit buildings for unloading direct from the cars to the exhibitors' spaces. A spur track was run to the U. S. Transport Dock so that freight from ocean-going vessels could be loaded on the Exposition's cars. Cars from the various transcontinental lines were brought to the grounds on barges, for the accommodation of which the Exposition built a freight slip.

The design of this slip follows the standard practice of the San Francisco Bay district in that the bridge forms a span between the boat and the shore. The bridge is hinged on the shore end, while the outboard end is suspended by cables which pass over sheaves to suitable counterweights. The counterweights are sufficient to overbalance the weight of the bridge and eliminate danger of dropping the bridge into the bay. To lower the bridge that portion of the counterweights required for overbalancing is raised by hydraulic means and the bridge is allowed to land on the shelf or recess provided in the bow of the barge. In operation, the live load on the bridge is divided between the boat and the shore supports, and the gallows frame carries only the weight of the bridge and counterweights—about 400,000 lb.

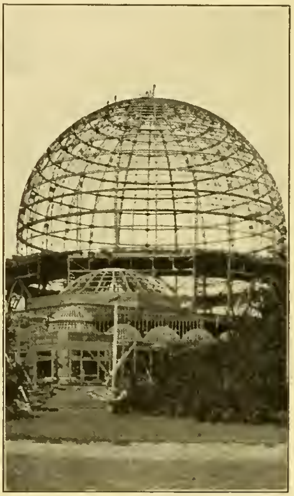

Fig. 11 Steel Dome of Palace of Horticulture

The hydraulic equipment consists of a vertical cylinder 28 in. in diameter and 12 ft. long, a motor-driven triplex pump and an accumulator. Cables run from the crosshead on the piston rod to the two auxiliary counterweights which rest on the main counterweights when the bridge is in the raised position. The water supply to the cylinder is controlled by a piston type valve fitted with cup leathers. This valve is operated by hand, but in case of overtravel of the bridge is automatically closed. The accumulator controls the motor operating the pump so as to maintain a constant pressure of 90 lb. per sq. in.

A 20-ton locomotive crane with a 35-ft. boom and grab bucket was secured at an early date, and, in addition to its use for unloading road material from cars, spotting cars and similar work, was found most useful for unloading heavy boxed trees and the erection of standards and statuary, an extension boom being used in many instances.

The work of the electrical department was expedited by the use of a 1-ton storage battery crane truck having a 2-ton trailer. While adapted for general delivery work, the greatest value of this was realized in transporting transformers and oil drums from the warehouse to the numerous building vaults. The transformers were loaded on to the trailer and hauled to a point opposite the vault, where they were lifted off the trailer one at a time and landed on dolly trucks. Planks were laid from the curb up the steep terraces and into the vaults, over which the dolly trucks were hauled by a

rope running around a block inside the vault and fastened to the back of the truck. Transformers up to 50 kw. in size were handled in this fashion with surprising ease and speed. After building an extension to the boom, the crane was used for setting gas and incandescent standards. No other type of equipment proved as useful as the battery truck crane for handling loads not exceeding one ton.

As the Exposition had undertaken to deliver all exhibits from the cars to the designated space, and as it was known from past experience that most of the exhibits would arrive in the 60-day period prior to the opening, this problem called for careful consideration. Transveyors consisting of 4-wheeled hand trucks for use in connection with special detached platforms were adopted for this service. The freight was loaded on the platforms which were later picked up by the transveyors and transported to the exhibit space.

Storage battery industrial trucks were also used for handling exhibits, a type being adopted which had an extension platform suitable for handling bulky goods. These trucks had a capacity of 2 tons each and frequently towed several transveyors in addition to carrying a full load. Motor cars and trucks have played no small part in the construction of the Exposition, in that they have enabled men and materials to be moved rapidly when and where required. With work scattered over a territory a square mile in area and over two miles in length, many cases arose where slower methods of transportation would have proven costly and delayed the completion of the work on time.

The Exposition required for the use of its construction departments 20 Ford automobiles and 14 trucks, of which two were 5-ton, three 2-ton, two 1½-ton, four 1500-lb. and three 800-lb. Just prior to and some time following the opening day this equipment was operated 24 hr. per day, and additional equipment was rented to meet the unusual situation at that time. While the construction program had been practically completed prior to opening day, there was an enormous amount of work incident to getting exhibits installed and cleaning up the grounds. It is estimated that within the last twenty-six hours something like 10,000 tons of debris of various kinds was hauled to the dump and burned.

The transportation of visitors within the grounds was solved to the apparent satisfaction of the public by the use of the auto train consisting of a small tractor and several trailers. The cars of the auto train are low enough to permit passengers to step directly on to the platform and the routes are such that the trains pass within 100 ft. of all buildings. The seats run the whole length of the cars, which have an aisle in the center for the conductor. Each car accommodates 20 passengers, and the gasoline tractor, which is equipped with a Ford engine, is capable of hauling three cars.

### FIRE PROTECTION

Certainly no exposition had a fire protection system comparable with the one installed at this one, and it may safely be said that few communities enjoy an equal security against fire. Located as it is within the city proper and close to the residential district, the Exposition represents a tremendous fire hazard to the city, and the problem of fire protection was carefully studied by the engineers of the Exposition in consultation with the Board of Fire Underwriters. In compliance with the general plan adopted, a high pressure water system was installed throughout the main portion of the grounds and as far west as the Live Stock section.

The system was designed to operate as a part of the city's auxiliary water supply system and to be capable of delivering 15,000 gal. per min. at any hydrant, at a pressure of 200 lb. per sq. in. The distribution system includes 52,000 lin. ft. of pipe in sizes from 6-in. to 16-in. lap welded pipe and Dresser all-steel couplings are used throughout, with extra heavy flanged cast-iron fittings and valves. All hydrants are of the flush type, set in circular concrete manholes with wooden covers. The hydrants have two 3-in. outlets and are spaced approximately 300 ft. apart. With the exception of the Fine Arts and Horticulture buildings, the high pressure system is brought into all exhibit buildings. Four 8-in. pipes are run into each building, one from each side, and serve the inside and roof hydrants, the automatic sprinkler system, the cornice sprinklers and the roof monitors.

The 8-in. valves controlling the supply to the buildings are kept closed, but the 4-in. by-pass valves are left open. This practice was adopted to limit the damage in case of a break inside the building. These 8-in. control valves are located outside the buildings, and in the same manholes are installed 6-in. cross connections to the low pressure supply, with check and gate valves, so that in the event of a failure in the high pressure supply the sprinklers will be fed from the low pressure system. The roof and inside hydrants have 3-in. outlets, and are so located that any portion of the roof or floor can be reached with 150 ft. of hose. The monitors have a capacity of 1500 gal. per min., and are set so as to play on the buildings opposite them as well as on the roofs on which they are located. The cornice sprinklers are arranged to produce a water curtain on the sides of the buildings which face one another and are less than 150 ft. apart.

Automatic sprinklers are installed in all exhibit buildings, with the exception of the Palaces of Machinery, Horticulture, Fine Arts, the Festival Hall and the administration portion of the California building. The domes in the eight buildings of the main group and the ceiling of the Palace of Machinery are not equipped with sprinklers, as the height is so great that the effectiveness of sprinklers is questionable.

In the design and construction of the buildings fire protection was borne in mind. Concealed spaces where a fire might flourish unobserved were carefully avoided, and heat curtains were used extensively to prevent circulation of air and insure the confinement of heat and operation of the automatic sprinkler and fire alarm systems. Reinforced concrete firewalls were built where the architectural requirements resulted in buildings being connected by colonnades or other decorative features. The exterior building walls were carried down to the ground surface and sheathed on the inside to a height of 12 ft. above the floor. The roofing used had a top sheet of either crushed brick or asbestos, and wire glass was used in all skylights, preventing fire being caused by anything falling on roofs.

Additional protection was afforded by hydrants connected to the domestic water supply system by the installation of 3-gal. chemical fire extinguishers and by suction pipes at the various parts to be used in connection with fire engines.

The fire department is operated as a part of the city's department, which answers all alarm calls on the E position grounds. Three fire houses, with equipment, are located on the grounds. A complete fire alarm system was installed

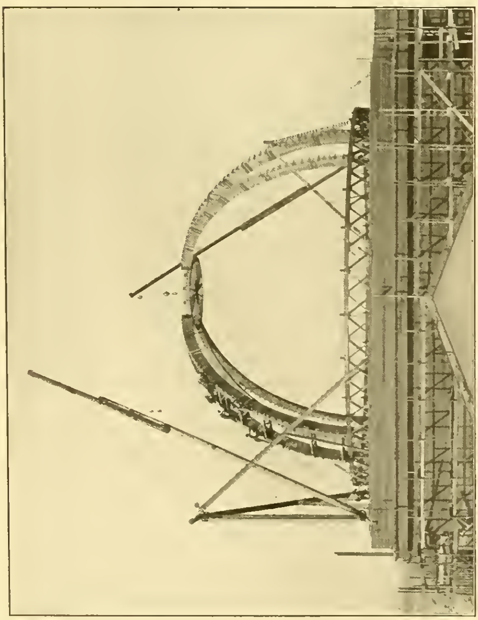

FIG. 12 TYPICAL TIMBER DOME CONSTRUCTION

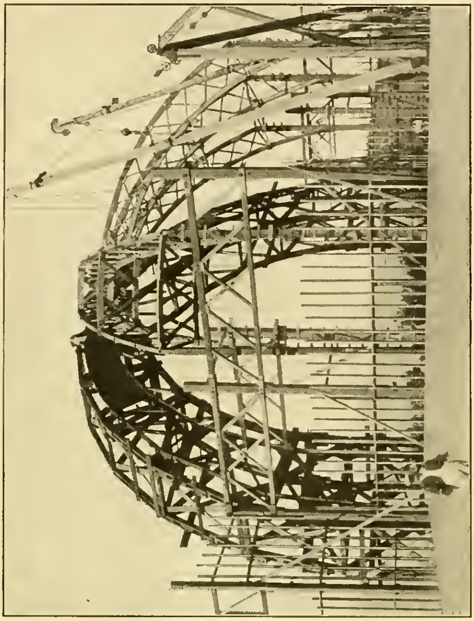

FIG. 13 FRAMING OF HALF DOME, FOOD PRODUCTS BUILDING

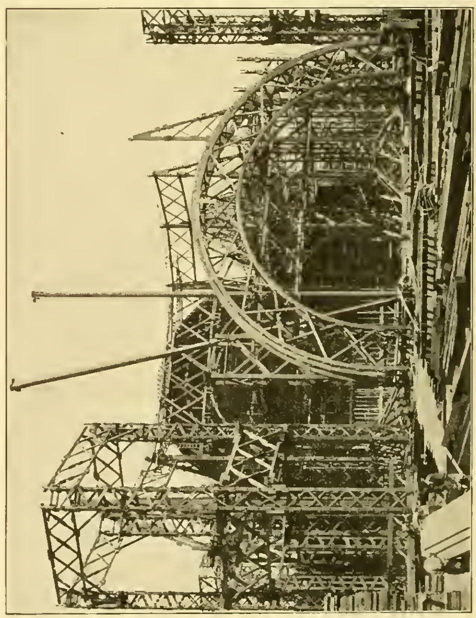

FIG. 14 FRAMEWORK OF FESTIVAL HALL

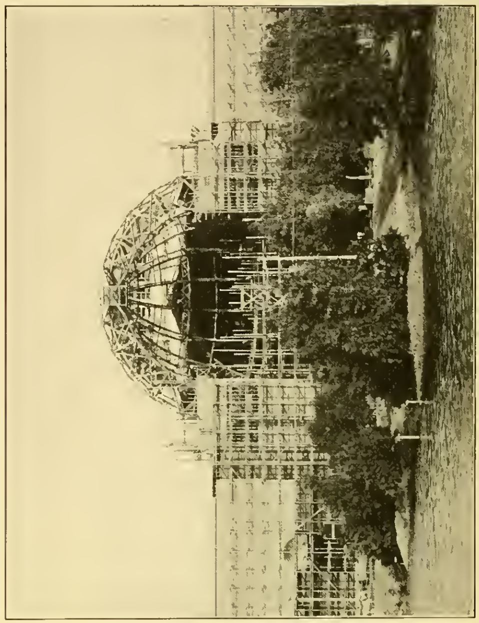

FIG. 15 FRAMING OF HALF DOME, PALACE OF EDUCATION

and a complete central office located in the Liberal Arts building is operated as an exhibit.

All exhibit buildings and many of the detached buildings, especially those having moving picture apparatus, are equipped with an automatic fire alarm system of the pneumatic tube type. Copper tubing not exceeding 1000 ft. in length is run around the ceilings or parts of buildings where heat from a fire would quickly affect the tubing. The tubing is 0.09-in. outside diameter with a hole approximately 0.045 in. in diameter. One end of each tube is connected to a detector, consisting of a sensitive metallic bellows such as is used in aneroids. In the event of a fire the pressure of the air in the tubing is increased, due to the expansion of the contained air and the bellows expands and closes an electric circuit, which in turn sends a signal to the central fire alarm station and to the annunciators placed at the building entrances to inform the fire department of the location of the fire. The bellows mechanism or detector is located in a steel cabinet which contains five detectors, each connected to about 1000 ft. of tubing. The buildings of the main group have at least five of these cabinets in each building, and some as many as eight, while the buildings of minor importance have a lesser number.

The fire protection measures adopted by the Exposition cost in the neighborhood of $900,000, but the fire losses up to August 1 have been insignificant and the security obtained has warranted the Exposition carrying only a nominal insurance on completed buildings.

### MECHANICAL FEATURES

*Power Plant.* With three large electric companies in the field, each capable of supplying needs of the Exposition, the necessity for building a power plant was not considered. The Pacific Gas and Electric Company, which furnishes electric energy to the Exposition, has a substation on the grounds, and the interesting feature of a power plant in operation is supplied by the Sierra and San Francisco Power Company, whose 18,000-kw. plant is located within the grounds, about 500 ft. east of the Palace of Machinery. This plant is operated in conjunction with a hydroelectric system for supplying energy to the United Railroads, and is an excellent example of a standby station with steam turbines and oil-fired boilers. Under an arrangement with the Pacific Gas and Electric Company, this steam plant is kept in operation continuously, so that in the event of an interruption in the regular source of supply it will carry the load of the Exposition.

*Heating and Ventilating Equipment.* With the exception of the spaces occupied as offices, no heating was provided for the main exhibit buildings other than the Service building, Administration building, Press building, Festival Hall, Palace of Horticulture and the Auditorium at the Civic Center.

The heating of Festival Hall is a departure from standard practice in that a system was installed using gas-fired hot-air heaters with forced circulation. While gas at 75 cents per 1000 cu. ft. is an expensive fuel, its use for the short period of the Exposition was justified by the saving in the initial cost of the plant as compared with a steam plant. The heaters and supply fans are located in two rooms, one on each side of the main auditorium. Each fan room contains two steel plate fans, each having a capacity of 1500 cu. ft. per min., and four hot-air furnaces, each capable of burning 440 cu. ft. of gas per hour. The arrangement is such that one fan serves two heaters and delivers air through registers located in the columns around the main entrance, while the other fan discharges into a plenum chamber beneath the raised side seats, openings being provided in the risers for the discharge of air into the auditorium. Air is removed from the auditorium by two multi-blade exhaust fans installed beneath and on each side of the stage, and having a combined capacity of 5200 cu. ft. per min. All fans are belt-driven by direct current motors equipped with armature control.

In the California building, the administration quarters are heated by 8700 sq. ft. of direct radiation with vacuum returns. Steam for the heating system and for the hot-water supply and kitchen equipment is supplied by two oil-fired, cast-iron boilers operated at a pressure of 5 lb. Ventilation for the ball room is secured by two 60-in. disc fans located in the attic space.

To provide the necessary heat in the dome portion of the Palace of Horticulture, which is essentially a large conservatory, a hot-water system with forced circulation was adopted. The hot water is supplied from a model boiler plant located about 90 ft. south of the main building, in which are installed two oil-fired cast-iron boilers equipped with vertical, rotary burners. Owing to the architectural requirements of the neighborhood, it was undesirable to use a tall stack, and smokeless combustion has been secured with a stack which is only 30 ft. high from the burners and terminates in the staff basket. Forced hot-water circulation is produced by two 4-centrifugal pumps designed to operate against a head of 40 ft., each direct-connected to a 7½-h.p. induction motor. Recording thermometers and a flow meter enable accurate records to be kept of the amount of heat delivered by the plant.

The heating required for the section beneath the dome was calculated on the basis of 3,725,000 cu. ft. of space, 54,650 sq. ft. of glass surface, and 15,470 sq. ft. of wall surface. It was assumed that there would be one complete change of air every three hours and a loss of six B.t.u. per hr. per sq. ft. of wall surface and 17 B.t.u. per hr. per sq. ft. of glass surface, making a total of 1,376,800 B.t.u. required per hour to maintain a temperature of 50 deg., with an outside temperature of 35 deg. The four rooms adjoining the dome section were figured for temperatures from 60 to 80 deg. fahr., which brought the total requirements of the building to 3,582,000 B.t.u. per hr., requiring the circulation of 190,000 lb. of water per hour, with an initial temperature of 250 deg. and a loss of 20 deg. Radiators of the cast-iron type were used instead of the customary pipe coils, with satisfactory results. Thermostatic control was installed in several of the rooms for regulating the temperature of ponds. The plan of using forced circulation and high temperatures made possible a material reduction in the size of the mains and the quantity of radiation required.

Minor heating installations were provided in various buildings, such as the Service building, which is heated by direct steam radiation of the single-pipe system, while the Press building is heated by the Rector system, which burns gas in connection with cast-iron radiator elements, the products of combustion being removed by means of a fan located in the basement. The offices in the Exposition palaces and most of the buildings erected by participants are heated by gas radiators or gas stoves of the radiant type, flues being provided to carry away the products of combustion.

Owing to the fact that the Auditorium in the Civic Center is a permanent, four-story, fireproof building, a modern heating and ventilating system was installed. In order that the main hall might be used for dances and other functions, a system of heating and ventilating was adopted which left the floor free of obstructions. Fresh air is forced through the openings in the balcony risers and grilles along the face of the balcony. The grilles are supplied from separate ducts, whereas the openings in the risers receive their supply from a plenum space beneath the balcony seats. Exhaust fans are provided to remove the air through large grille plates beneath the balcony, along the side walls and through smaller grille plates above the balcony, and just below the base of the auditorium dome.

For supplying fresh air, two fans are installed in the basement, each having a capacity of 145,000 cu. ft. per min. Two main exhaust fans, each capable of handling 70,000 cu. ft. per min., are installed in the attic, and two exhaust fans of 75,000 cu. ft. per min. capacity in the basement. Additional supply and exhaust fans are provided for the banquet rooms, toilets and kitchens, these fans having a total rating of 39,000 cu. ft. per min. The fans, of which there are 18, and the vacuum pumps, are belt-driven by motors aggregating some 250 h.p. Heating coils are used in connection with the various fresh air supply fans, and provision has been left for air washers should they ever be found necessary. Direct radiation is used for the upper corridors, convention halls and offices.

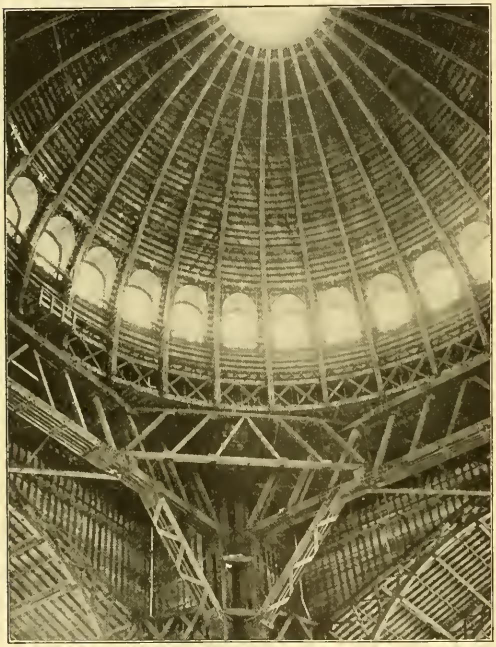

Fig. 16 Interior of Dome, Mines Building

*Pumping Plants.* In addition to the pumping plant described under the heading of Water Supply, numerous pumping equipments were installed throughout the grounds in connection with the fountains, the pools, the drainage beneath the buildings, the handling of sewage and the supply of salt water. Belt-driven centrifugal pumps were adopted as a standard, as they permitted the use of rented motors, were lower in first cost, and carry a higher salvage than direct-connected pumps. Another reason for the adoption of the belt drive was the ease with which the pump speeds could be changed to meet conditions of operation different from those planned.

The pumping equipment of a fountain is a simple problem compared with that of laying out the distribution piping and deciding on the form, size and adjustment of the nozzles. It was found that the use of lead pipe for connection to nozzles expedited the work of adjustment, and in many cases the nozzles themselves were formed from lead pipe. Experience indicates that valves or cocks should not be placed close to nozzles as they disturb the flow of water and prevent the realization of a smooth and solid stream. Where groups or decorations are liable to be constantly wet, they should be made of cement, as staff will fail, even though the water may not play directly on it. If canvas is used for lining basins or pools it should be painted on both sides and thoroughly protected against damage from workmen's shoes. Sixteen motors, aggregating 755 h.p., are used for driving pumps to produce water effects.

*Transfer Table.* The arrangement of the Palace of Transportation necessitated bringing all rolling stock into the building on one track and distributing this equipment to 14 exhibit tracks by means of a transfer table. This transfer table had to be designed to carry the largest locomotives and cars of which, up to that time, there was any record. A standard steel transfer table would have cost from fifteen to twenty thousand dollars, and its salvage value would have been problematical. The transfer table as built cost $7000, exclusive of foundation. Its deck is 76 ft. long, and it is made up of timber stringers on which are laid the ties and track. This deck is supported on 14 trucks, two trucks to a track. Each pair of trucks is tied together with stringers which carry the deck and transmit the load to the trucks through special steel bolsters. No springs are used and, barring the flexibility due to the timber work, the table is a rigid structure.

The transfer table has a 300 ft. length of run and is moved back and forth by two hauling lines and two tail lines. One hauling line and one tail line are attached to the deck near each end, and this arrangement keeps the table in alignment at all times. Each hauling line, with its companion tail line, is rove on one drum in such a manner that as one line runs off the drum the other fills the space vacated. This method successfully prevents the cables from overriding and admits the use of a smooth face drum. The two drums are geared to a countershaft which is belt-driven by a 35-h.p. variable-speed induction motor.

*Traveling Cranes.* To facilitate the installation of heavy exhibits three bays in the Palace of Machinery were equipped with traveling cranes. The center bay has two 30-ton cranes with 5-ton auxiliary hoists, and each adjacent bay has a crane of 20 tons capacity. These cranes have a span of 67 ft. 8 in. and are of standard steel construction, with 3-phase, variable-speed motors. These cranes were all obtained on a rental basis, the sum of $13,600 being paid for their use,

which amount also includes the erection and dismantling of the cranes.

*Refrigeration Plants.* Refrigeration service was considered desirable in the Palaces of Horticulture and Food Products, and refrigeration plants were accordingly installed in these two buildings. The apparatus was installed by exhibitors, but was operated at the expense of the Exposition, which in turn sold refrigeration service to various exhibitors and participants. Subsequent events, however, proved that the use of small individual plants, or ice, would have been more satisfactory than a central plant and distribution system, because the needs of the consumers were nominal.

In the Palace of Horticulture the central plant is an exhibit of the Automatic Refrigerating Company. The principal feature of this installation is its automatic control, a thermostatic switch starting and stopping the motor according to the changes in temperature of the refrigerated space. The water for the condenser is automatically regulated to meet load requirements and is shut off entirely when the motor stops. Should the water supply fail the motor will stop automatically and will start again when the water supply is resumed. The plant has a rated capacity of 3½ tons of refrigeration per day. The piping is 1000 ft. long, 1¼-in. diameter, and is covered with cork insulation. Although this plant receives but little attention, the results are most satisfactory.

The central plant in the Palace of Food Products was installed as a working exhibit by the York-California Construction Company and consists of two double-cylinder, double-acting, vertical compressors—one of 20 tons and the other of 4 tons refrigerating capacity, both belt driven by motors. Brine is chilled and circulated through the distribution piping to the various exhibits. This piping is not covered, as it is cheaper to waste power during the short period of the Exposition than to provide insulation. To prevent waste of water an inexpensive cooling tower was built 4 ft. by 8 ft. in section and 25 ft. high. Spray heads were installed half way from the top of the tower and the air for cooling purposes taken from beneath the building floor and blown through the tower by a 30-in. disc fan. The discharge of air from the tower directly into the building has not proven objectionable.

*Repair Shops.* Early in the progress of construction work machine and blacksmith shops were fitted up to care for general repair work and later for the manufacture of electric standards and fixtures. All of the iron work used in the construction of the gas and electric standards was fabricated in the Exposition's shops.

### ELECTRICAL FEATURES

One of the earliest problems for settlement was that of securing a supply of electrical energy for the construction and operation of the Exposition. Owing to the fact that there were three electrical companies, with steam stations within the city and connections to extensive hydroelectric systems, the Exposition was in a favorable position to negotiate for the purchase of electric energy.

In order to arrive at a figure sufficiently close for the purpose of making a contract for electric service, the areas of the buildings, courts, gardens and avenues were computed and various light intensities assumed for each. Tungsten units were figured for use in the buildings and courts, and magnetite arc lamps for the gardens and avenues. The load in the concessions area was assumed as being 80 per cent of the connected load in the concessions area of the St. Louis Exposition. The amount of load for exhibitors was guessed at, as there was no information available on this point. These rough calculations indicated that the average peak would be 8500 kw., with a maximum of 11,500 kw. during the winter season when the day load would overlap the evening load. It was decided to compare proposals on the basis of a 12,000-kw. maximum load and a load factor of 30 per cent.

On Feb. 28, 1913, a contract for supplying electric service was entered into with the Pacific Gas and Electric Company, under the terms of which the Exposition was to pay 2 cents per kw-hr. during the pre- and post-exposition periods, and during the actual period of the Exposition a fixed charge of $18,000 per month, plus an energy charge of 0.6 cents per kw-hr. For the fixed charge named the Exposition was entitled to take loads up to 15,000 kw., but was

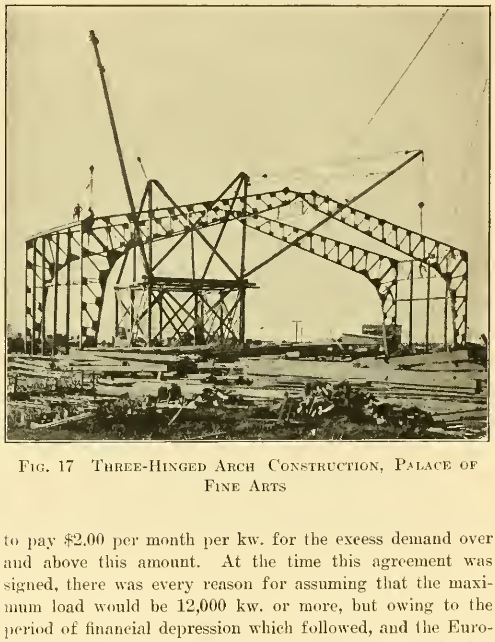

Fig. 17 Three-Hinged Arch Construction, Palace of Fine Arts

to pay $2.00 per month per kw. for the excess demand over and above this amount. At the time this agreement was signed, there was every reason for assuming that the maximum load would be 12,000 kw. or more, but owing to the period of financial depression which followed, and the European war as a climax, a large number of prospective foreign and domestic exhibits were withdrawn, and the maximum load realized has not exceeded 8100 kw., with an average maximum of 7880 kw. On the basis of this average maximum and the charge for energy, the cost per kw-hr. has averaged 1.7 cents.

An agreement was entered into with the Pacific Gas and Electric Company, whereby it was to furnish the Exposition, for use during the Exposition and during the construction and dismantling periods, all of the electrical apparatus, instruments, materials and appliances which might be required, except building wiring, searchlight projectors and other special apparatus not in general use by power companies. For the use of this apparatus the Exposition agreed to pay 5 per cent of the cost of the apparatus to the Pacific

Gas and Electric Company as a rental, independent of the length of time the apparatus had been in use, and to pay outright for all apparatus not returnable.

Included in the contract for electric service was the requirement that the power company should install a substation on the grounds and a 5000-kw. steam standby plant. This requirement was later modified by an agreement between the Pacific Gas and Electric Company and the Sierra and San Francisco Power Company under the terms of which the Pacific Gas and Electric Company installed its sub-station in the west end of the Sierra and San Francisco Power Company's power house, and received standby service from its 18,000-kw. turbine plant. As the power house mentioned is within the grounds and the plant was to be kept running during the period of the Exposition, it was felt that the protection of service thus secured was even greater than under the terms of the original contract.

In fulfilment of the terms of the contract, the 60-cycle, 3-phase energy used by the Exposition is generated at Station A, which is in the southern part of the city. This station has a capacity of 52,000 kw. in steam prime movers and, in case of breakdown or overload, takes electric energy from the power company's 60,000-volt transmission lines which terminate at Martin Station, at the southern boundary of the city, where the voltage is reduced to 11,000 volts. To transmit this energy three 4/0, 3-conductor, 11,000-volt cables run underground from Station A direct to the sub-station on the grounds, known as Station F.

*Primary Distribution System.* Power from Station F is distributed throughout the grounds by means of fifteen 3-conductor, 3-phase, 4100-volt feeders and two 11,000-volt, 3-conductor, 3-phase feeders. With the exception of the overhead lines in the concessions district, and the extreme westerly end of the grounds, the distribution is from an underground system.

*Secondary Distribution.* With the exception of the areas mentioned, where overhead lines are installed, alternating current at secondary voltages for light and power purposes is taken from transformer vaults which are in reality minor sub-stations in which the primary cables terminate and the high-tension switch gear and transformers are installed. All buildings are furnished with energy for light from 3-phase, 4-wire mains connected to the distribution boards on the transformer vaults. This arrangement provides 115 volts from any conductor to neutral, and consumers are served from one, two or three of the phases, depending upon the size of their load. Power is supplied from separate transformers and the distribution is at 230 volts from 3-phase, 3-wire mains.

Fig. 18 Framing of Palace of Machinery, Showing Connections at Intersections of Bays, also Framing for Crane

*Electric Rates.* Electric service is furnished at flat, meter and special rates, as follows:

Flat rate: Electric installations having a connected load to any given service of less than 2 kw. are charged at the rate of \$15 per month per kw. of connected load, with a minimum of \$2.50 per month where the load is 166 watts or less. This rate is based on the understanding that the entire connected load will not be used more than 240 hours per month.

Meter rate: Consumers having connected loads in excess of 2 kw. are provided with meters, and electric service is charged for on the basis of \$2.50 per month per kw. of connected load, and an energy charge of 5 cents per kw-hr., with

a reduction of 0.1 cent for each 1000 kw-hr. used per month up to 20,000 kw-hr. and 3 cents per kw-hr. for the balance.

Special rate: All exhibitors in the main palaces were given lighting service at rates 25 per cent less than the foregoing, and power service at a rate of 3 cents per kw-hr. The connected load was estimated from the manufacturer's rating of the apparatus and in most instances was the maximum demand.

An exception to these rates was made in order to encourage participants in the States and Foreign sites to illuminate their buildings, and no fixed charge was made on lights installed for exterior decorative purposes.

*Direct Current System.* Direct current for the operation of searchlights and projectors is generated by two 1000-kw., 250-volt generator sets and two 250-kw., 125-250-volt balancer sets. These units are installed at the various load centers in order to reduce to a minimum the distribution copper required, but are all operated in parallel.

*Underground Conduit System.* The underground conduit system is approximately 30,000 ft. in length, and comprises 300,000 ft. of duct. The short life of the Exposition necessitated an economical design, and a type of conduit construction was adopted based on the use of fibre duct with 1/8-in. walls (Linaduct), and wooden manholes. The ducts were laid on a box or trough extending between manholes which varied in size to suit the number of ducts. The space between the ducts and the box was filled with sand sluiced into position with water, except at the entrance to the manholes, where concrete was used for a distance of 4 ft. to prevent the ducts being displaced by cable pulling operations.

The boxes were made up in the mill and delivered in 14-ft. and 20-ft. lengths, which were made continuous by splice pieces nailed to the sides and bottoms. The load on the bottom boards was transferred to the sides by means of 1-in. by 4-in. strips fastened to the bottom and sides and spaced 4 ft. apart, the corners held by iron straps. After the boxes were filled flush with sand, pieces were nailed across the top. This form of construction proved to have great mechanical strength, and there were many instances where building materials were piled upon exposed lines, and spans of 10 ft. or more were left unsupported as a result of undermining for other utility mains, without damage to the conduit. The conduit system was laid before the streets were paved, but was not damaged by the teaming or road rolling. In fact, a damaged duct or a misplaced one has never been discovered.

Fig. 19 Framing of Palace of Machinery

*Lighting Standards.* The design of the foundations for arc standards was given careful study, as most of the standards were to be set in a soft dredger fill. The standards fitted with banners, in particular, were liable to blow over in high winds, as the exposed area was large and the arrangement ideal for catching the wind. These poles are 40 ft. high, 13½ in. in diameter at the ground line, 4 in. in diameter at the top, and carry from 5 to 7 arc lamps which weigh 100 lb. each. The banners have an area of 50 sq. ft. with the center of pressure from 25 ft. to 35 ft. above the ground line. The other design of arc standard has a staff decoration on the top which, owing to its size, shape and weight, presented almost as severe a problem as the banner type.

Considering that there are 200 of these standards, the foundations for which involved considerable expenditure, experiments were carried out with various forms of foundations to determine the least expensive type of construction which would meet the rather unusual conditions. The result of these experiments was the adoption of a reinforced concrete slab placed 6 in. below the ground surface and supported by piling. The piling consisted of 2-in. by 6-in. pieces which were jetted into place in advance of the concrete work. Spikes were driven near the tops of the piling, which were embedded into the concrete, and served to transmit to the piling any uplifting forces due to the turning moment developed by the wind. The concrete slab was made in the form of a cross to insure a sufficient spread with the minimum of material, and a hole was left in the center to receive the pole, which was grouted in after setting. These foundations cost $35 each, and although storms have been experienced which tore away the banners in some instances, none of the foundations has failed.

*Illumination.* With the realization that illumination had become a branch of engineering, a specialist in that field was employed to design the general scheme for lighting the Exposition, which was later adopted and made the basis for detailed plans and estimates. Slight changes were later made to obtain the desired effect.

The perfection of the illumination produced is largely the result of an appreciation by the engineers of the aesthetic qualities of the work of the architects and artists, and it was therefore possible to secure their coöperation, which was of the greatest value, particularly in the settlement of prob-

lems relating to color, and the location, scale, mass and decoration of the lighting standards.

The general scheme of illumination adopted was to use flood lighting from hidden projectors and massed lighting from arc standards, exposed sources being used in gardens and along roadways where the treatment admitted of incandescent standards. The illumination was described in detail by the writer in the Feb. 13, 1915, issue of the *Electrical World*.

The flood of light on the various towers is produced by searchlight projectors hidden on the roofs of buildings and outlying structures. For the flood lighting of the 6 towers, the Palace of Fine Arts and the large groups of statuary, thirteen 30-in. and two hundred 18-in. searchlight projectors

Fig. 20 Battery Truck Crane with Extension to Boom for Handling Standards

are used. Most of these are fitted with dispersion doors which spread the beams anywhere from 10 to 40 deg., depending upon the design of the strip lenses in the door. In some instances double doors are used, one of which spreads the beam horizontally and the other vertically.

The searchlight projectors are of the manual control type and most of them are equipped with parabolic mirrors, while the balance have Mangin mirrors. The latter type of mirror is not suitable for lighting building surfaces, as it produces a spectrum at the circumference of the field illuminated, but for lighting groups which occupy only a portion of the field this type of mirror is satisfactory. Gelatine color screens are employed in connection with the searchlight projectors and by their use the color tone of the Exposition can be readily changed.

The strong light from the projectors would cause deep and sharp shadows, and to neutralize this effect the shadows are illuminated by concealed incandescent lamps which are dipped an orange color. On the towers these lamps are located behind the columns, at the floor levels. To have wiped out the shadows entirely would have resulted in a flat effect, and no feature has contributed more to the charm of the lighting than the treatment of the shadows with color.

A decorative feature is the use of imitation jewels in connection with the illumination of the upper portion of the main tower, where over 100,000 are used, while 25,000 are used elsewhere. The jewels are made of glass and vary in size from 21 mm. to 47 mm. They are cut with facets similar to those of a diamond, and a small mirror is mounted behind each to increase the number of flashes obtainable. These jewels were made in Austria and their cost ranged from 33 cents for the 47-mm. size to 6 cents for the 21-mm. size. Although the jewels are of various colors, most of them are amber. They are mounted in holders which are attached to supporting hooks, allowing them freedom to swing in the air currents. Under the powerful rays of the searchlights the jewels sparkle and glitter and contribute an element of action and color which is most striking. The jewels have never been cleaned and the difference in appearance after 5 months' use is not noticeable.

The flood lighting feature for the building wall surfaces is provided by magnetite arc lamps set on ornamental standard 30 ft. high and spaced from 60 ft. to 75 ft. apart. Two types of standards are used, one having a large curved shield of staff with three openings fitted with orange colored translucent fabric; the other has a combination of three canvas banners painted with heraldic emblems. The design of both types is such that the lamps are not in the line of sight, but allow a small amount of colored light to pass. Lamps were used on these standards in combinations of 2, 3, 5 and 7, depending upon the distance of the standards from the building walls. Some light was reflected back from the building walls, but not enough to illuminate the adjacent avenues, and additional lighting was provided by means of single-light electroliers made of staff and equipped with 250-watt Mazda lamps and 18-in. glass globes.

Similar electroliers, carrying from 1 to 21 globes, lighted the South Gardens, Court of Palms and the entrances to some of the other courts. Special globes were used which, while they contributed a mellow diffused light at night, produced a discordant effect during the day, owing to their whiteness as compared with the color tone of the travertine finish of the buildings. A lacquer, into which color was mixed, was used to overcome the objectionable appearance of the globes.

The globes were all in position at the time it was decided to spray them, and for this purpose a portable rig was made consisting of an air compressor and four potter's wheels, which was moved around from standard to standard, the globes placed on the wheels and sprayed with the lacquer by means of an air brush. The lacquer coating caused some loss of light, but not enough to make a noticeable difference in the illumination.

An element of life is given to the night picture of the Exposition by the buildings appearing to be lighted up inside, which effect is produced by Mazda lamps fitted with tin reflectors and suspended back of the various building openings. The color effects in some locations are obtained by using dipped lamps and in others by painting the glazing.

The kaleidoscopic colors and shapes which appear in motion on the glass dome of the Horticulture building are

produced by twelve 30-in. searchlight projectors placed beneath the center of the dome and arranged to project their beams through revolving lenses and color screens. Eight color screens and twenty lenses are used in connection with an opaque sector disc. These three elements are mounted on a vertical shaft and slowly revolved at slightly different speeds. Various combinations of shapes and colors are thus projected upon the dome, but the effects are rather thin, owing to the fact that the quality of glass used does not intercept a sufficient amount of light.

Without doubt the most spectacular feature of the illumination of the Exposition is the so-called scintillator, located on the Yacht Harbor. The equipment consists of forty-eight 36-in. searchlight projectors of the manual control type and is used in connection with pyrotechnic displays and steam effects, in addition to being used nightly in the form of a great fan as a background to the illumination. The color screens used in connection with these lights are wooden frames with gelatine sheets held between chicken netting. The gelatine sheets are waterproofed with spar varnish for protection against moisture. The searchlights are operated by 52 U. S. marines under a commissioned officer.

The illumination of the Exposition buildings and grounds, not including the States and Foreign section, produces a load of 5216 kw., of which 1700 kw. are used for the searchlights, 450 kw. for the arc lights and 3066 kw. for the incandescent lighting. The cost for electric service chargeable to illumination is $630 per night, and for labor, repairs and maintenance $125 per night. The lighting of the emergency gas lights costs about $35 per night, and the gas lighting in the States and Foreign sites about $40 per night. In round numbers the cost to the Exposition for lighting is $830 per night, which sum includes all operating costs, but no capital charges.

### GAS DISTRIBUTION

Gas for the use of the Exposition and its participants is purchased wholesale from the Pacific Gas and Electric Company and is retailed by the Exposition through a system of high-pressure distribution mains which were installed by the company for this purpose. The gas used is manufactured from oil at the company's Potrero plant and is transmitted across the city at a pressure of 80 lb. Two Thomas electric gas meters measure the high pressure gas supplied to the Exposition. The distribution mains extend throughout the grounds, an 8-in. ring surrounding the main group, with an 8-in. loop into the States and Foreign sites, and a 4-in. loop into the Zone. Other areas are supplied from 4-in., 3-in. and 2-in. mains laid to form loops or rings. Lap welded pipe was used for the 8-in. and 4-in. mains and standard pipe for the smaller sizes. In all there were 100,000 ft. of pipe laid. All joints and connections to the mains were welded by the oxy-acetylene process and the connections were tested with high pressure gas before backfilling.

The various palaces were equipped with low-pressure 4-in. and 6-in. ring mains which were fed at one or more points by 3-in. service connections from the high-pressure mains. Pressure governors within the buildings reduced the gas pressure to 6-in. water gauge, and oil seals were installed close to the governors for protection against an increase in pressure in the domestic distribution system due to a failure of the governor. Consumers located within the Exposition buildings are supplied from the ring mains, while those in the States and Foreign sites are connected to the high-pressure mains, with a regulator set on their premises to reduce the pressure. In the States and Foreign sites, and on top of all kiosks, high-pressure gas lamps are installed. Each lamp has a small regulator which reduces the pressure to 3 lb., but oil seals are not used in connection with these installations. Some 257 of these lamps are in use, with excellent results. Low-pressure gas arcs are installed on poles along the Zone for emergency lighting. The distribution of gas lamps throughout the grounds is such that in the event of a failure of the electric service, people could get about without inconvenience.

With a view to public safety gas lamps were installed for

Fig. 21 Loco Crane with Extension Boom Raising Statuary

all emergency and exit lighting. Gas is sold to consumers at the rate of $1 per 1000 cu. ft. for the first 50,000 cu. ft. used in any one month, and 80 cents per 1000 for a consumption in excess of this amount up to 300,000 cu. ft., at which point a sliding scale is applied which reduces the price to about 70 cents per 1000 cu. ft. for some of the large consumers.

Gas is the only fuel allowed on the grounds, with the exception of plants which are sufficiently large to warrant the employment of an engineer. In such installations the use of oil-fuel is permitted.

The average quantity of gas used on the grounds is from 12,000,000 to 15,000,000 cu. ft. per month.

### WATER SUPPLY

Preliminary estimates indicated that the average consumption of water would be about 1,258,000 gal. per day with a

possible maximum of 2,525,000 gal. per day. In the absence of any exact data for guidance, and in order to be on the safe side, the pipe sizes of the distribution system were figured on the assumption that the average consumption would be 2,000,000 gal. per day and the maximum 3,500,000 gal. per day. The maximum rate of flow was assumed to be $1\frac{1}{2}$ times the maximum daily consumption.

*Sources of Supply.* In view of the fact that there was the possibility of San Francisco acquiring the plant of the local water company by condemnation proceedings, the Exposition found it impossible to arrange for a water supply from this source. A survey of the situation indicated the possibility of securing about 800,000 gal. per day from the water supply system of the Presidio and the balance by developing the underground storage waters in and near Golden Gate Park, with a small additional amount of water from wells on the grounds.

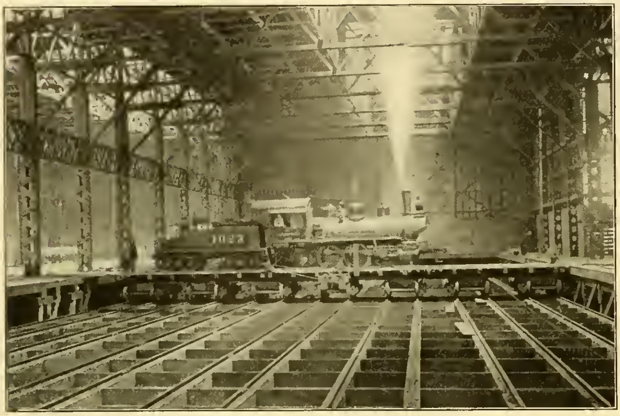

Fig. 22 Transfer Table, Palace of Machinery

The Presidio allowed the Exposition the use of one of the compartments of its storage reservoir and the arrangement was such that when the Presidio's compartment was full the excess would spill into the compartment allotted to the Exposition. This reservoir is at an elevation of 384 ft. and the capacity of one compartment is 3,000,000 gal. As soon as this contract was closed, the U. S. Government allowed the Exposition to tap its 8-in. line to Fort Mason, which passed through the grounds, thus giving the Exposition immediate relief from a threatened shortage of water during the construction period.

*Golden Gate Park Supply.* No time was lost in making tests for water in the vicinity of Golden Gate Park, for it was generally known that a considerable quantity of water was to be found in that district due to the absorption of the rainfall by the sandy soil. Seepage downward is prevented by a stratum of clay at a depth of from 60 to 90 ft. from the ground surface, but there is a flow toward the ocean at a rate of from 10 to 30 ft. per day.

From a careful study of the situation, it was estimated that a supply of 1,000,000 gal. per day could be relied upon during the period of the Exposition, which estimate was to a degree verified during the investigations by the work of a sewer contractor in the vicinity of the proposed plant, who found it necessary to pump 1,000,000 gal. per day to unwater his trench. The first step taken was to construct in the westerly end of Golden Gate Park an infiltration sump similar to that used by the Park Commission for their supply of irrigation water. This sump was made 200 ft. long, 14 ft. wide and 30 ft. deep. Tongue and groove sheet piling was used to keep out the surface water, while removable screens placed near the bottom collected the water of desired quality. This sump developed a yield which indicated it could be depended upon for 350,000 gal. per day, but owing to the high cost of construction for the output secured, it was decided to try sinking wells, although it was brought to the notice of the engineers that wells had been tried before in that territory and abandoned on account of inability to keep out the sand.

The desperate situation justified taking a chance and a test-well was bored just outside the park, which was brought up to a capacity of 368,000 gal. per day without encountering any difficulty with sand. This well was 80 ft. deep, with an outside casing 20 in. in diameter and an inside casing 16 in. in diameter.

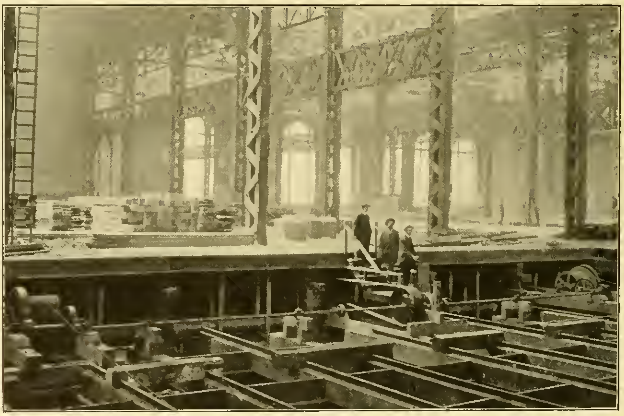

Fig. 23 Hauling Gear for Transfer Table

Both casings were perforated with slots having $^1/_{16}$-in. openings, and the annular space between casings filled with gravel ranging from rice to pea in size. Encouraged by the performance of this well, four more of the same size and type were drilled in the same vicinity, varying in depth from 70 to 87 ft. The material encountered was a fine beach sand having an effective size of 0.18 mm. and a uniformity coefficient of 1.55. The wells were all located within an area of 650 ft. square, and it was assumed that while one well would probably yield 260,000 gal.

per day during the Exposition period, mutual interference would bring their combined capacity to about $2\frac{3}{4}$ times the capacity of one well, or 650,000 gal. per day for the five wells.

*Filtration Plant.* Considering shallowness of the wells and the possibility of contamination due to the water shed being inhabited, it was decided to filter the water and treat it with chlorine gas. Realizing that the plant would probably end its usefulness with the Exposition, a design was adopted in which first cost was the prime consideration. The elements of the plant consist of a measuring chamber into which the water is discharged from the wells and sump, a raw water reservoir where the coagulant is introduced, three rapid sand filters and a clear water reservoir. A uniform flume type construction was used for all elements, the adoption of which simplified the framing, foundations and erection. A bulkhead placed near one of the raw water reservoirs forms a measuring chamber 12 ft. 6 in. by 9 ft. 6 in. by 9 ft. 3 in. deep. Two 4-in. by 12-in. submerged orifices are located in this bulkhead. The supply lines from the sump and wells discharge into this chamber and are fitted with control valves actuated by floats located in the raw water reservoir. A differential gauge indicates the difference in levels between the water surfaces in the measuring chamber and raw water reservoir, from which the rate of flow is determined.

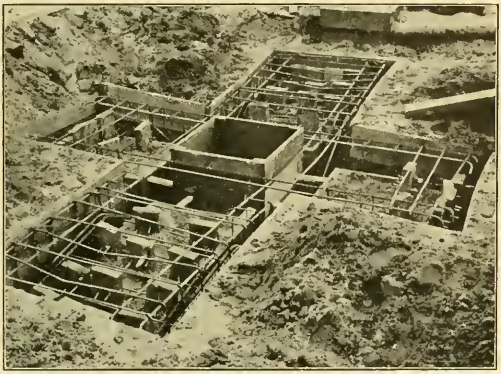

Fig. 24 Footing of Lamp Standard, showing Reinforcement and Anchorage

The raw water reservoir is 64 ft. long by 12 ft. 6 in. wide and 8 ft. deep, its size having been determined by the period of time required for coagulation with four filters operating at maximum rate. The treated water flows from this reservoir to the filters through a 2-ft. by 3-ft. flume located between the row of filters. The supply to each filter is controlled by a shear valve located in the side of the flume. At the far end of the flume is an overflow weir which comes into use in case the water level in the raw water reservoir exceeds the predetermined height.

Three filters, each rated at 500,000 gal. per day, are in operation, but space and pipe connections are available for a fourth unit should the necessity arise. The units are 14 ft. 8 in. long, 12 ft. 6 in. wide and 8 ft. deep. The collector system employed is a departure from the usual types and has been most successful in operation. The design was developed by Prof. Charles Gilman Hyde, and in addition to its effectiveness has the merit of low first cost. The collector in each filter consists of a header, rectangular in section, bolted to the bottom of the filter. The effluent pipe is run through the bottom of the filter to the center of the header from which point the header is tapered so that the loss in head is fairly uniform throughout its length.

On the top of the header, openings are provided for the 3-in. nipples which make the connection to the $2\frac{1}{2}$-in. lateral pipe. These laterals are placed on 6-in. centers and extend the full width of the filter. Holes $\frac{5}{16}$ in. in diameter and 3 in. apart are located on the under side of the laterals. The loss of head through each of these small holes being the same, and great as compared with the losses elsewhere, insures a uniform collection of the effluent. Coarse gravel was placed in the bottom of the filter to a point 2 in. above the laterals, then three layers of graded gravel, each 3 in. thick, followed by 26 in. of sand having an effective size of 0.35 mm. and a uniform coefficient of 1.5.

The depth of water over the top of the sand is 30 in. The effluent flows from each filter through an 8-in. riveted steel pipe to the clear water reservoir, where an effluent controller of simple design is installed. The controller is set in a compartment located within the clear water reservoir with water connection thereto through a submerged weir. The level of the water in this compartment is kept at a constant height by a float actuating the controller, which insures a fairly constant rate of flow. Should the water in the clear water reservoir reach the overflow point, an auxiliary float closes the effluent controller. Wooden floats are used throughout and the simplicity of the effluent controller may be realized by the fact that three of them, 8 in. in size, cost less than $50 to make. All of the measuring or controlling

Fig. 25 Banner Type Lighting Standard

devices used in this installation are home made, and while some of the equipment may appear to be crude it does the work with all of the accuracy essential to operation.

The washing of the filters is done by the reverse current method, the water being forced through the collector system at a high velocity. A 10-in. centrifugal pump is used for this purpose and the rate of washing is 2-ft. vertical rise per min. in the filter, which is equivalent to 15 gal. per min. per sq. ft. of sand surface. Washing at this rate raises the sand bodily about 12 in. and keeps it in motion. Two wooden V-troughs in each filter collect the wash water. No appreciable disturbance of the gravel has been noted, although no means have been provided to prevent it. It takes about 5 min. to wash a filter, the wash water being applied for 2 min. Owing to the water being practically free from turbidity, it is only necessary to wash the filters every 10 hours.

*Clear Water Reservoir.* The clear water reservoir is 96 ft. long, 12 ft. 6 in. wide and 7 ft. 6 in. deep and holds 60,000 gal. of water. From the bottom of this reservoir, and located on the side directly opposite that on which the effluent controllers are situated, three 6-in. suction pipes are run, one to each of the three units in the main pumping plant. Over that part of the reservoir where the controllers are installed is a house which contains the sterilizing equipment.

This equipment is the exhibit of the Electro Bleaching Gas Company, of New York, and consists of a gauge board, shut-off valves, gauges and a pressure reducing valve. The quantity of gas applied is indicated by the position of a small glass float located within a tube.

The apparatus is easy of adjustment and does not require a skilled attendant. In order to keep a check on the quantity of chlorine used, the cylinder in use is kept on a platform scale, and it has been found that the quantity determined from the gauge readings checks within 1 per cent of the weighed quantity. The chlorine is applied at the rate of 3 lb. per 1,000,000 gal. of water, and bacteriological tests have demonstrated that the water is at all times perfectly safe for drinking purposes.

*Main Pumping Plant.* The water is taken from the clear water reservoir and pumped to the Presidio reservoir by three 5-stage 6-in. centrifugal pumps, each rated at 500 gal. per min. against a pressure of 220 lb. These pumps are belt driven by 125-h.p. induction motors. The pump house is located alongside of and about 5 ft. lower than the clear water reservoir, so that the pump suction lines are under a pressure head at all times. The main pumps force the water through a 12-in. main to the Presidio reservoir, which is 19,300 ft. from and 365 ft. above the pumping plant.

Fig. 26 Court of Four Seasons, with Scintillator in Distance

*Trouble with Wells.* While no trouble has ever been experienced with the test well mentioned heretofore, the other four wells gave trouble from the start. It is hard to explain this difference, as the wells were all of identical construction and the formation encountered was the same for all. The pumps used in these five wells are vertical, 3-stage, centrifugal pumps, belt-driven by 20-h.p. motors, and operate at 1400 r.p.m. against a 75-ft. head. A foot valve was placed below the pump, but as it was the cause of the pump becoming choked with sand it was discarded and a check valve placed in the discharge line from the pump. Each of the wells in turn started to sand up as soon as any considerable amount of water was pumped, with the result that the pump soon choked and it became necessary to withdraw the pump and sand-pump the well.

Although the pumps were supposed to be adapted for

handling water containing sand, the bronze bearing bushings were in some instances cut out with one day's operation. This trouble was largely overcome by discarding the tubes which enclosed the shafting, and using leather rings above and below each bushing, securely fastened thereto and fitting snugly on the shafting. By operating the pumps at capacities between 60 and 100 gal. per min., depending upon the well, continuous flow could be obtained, but a certain amount

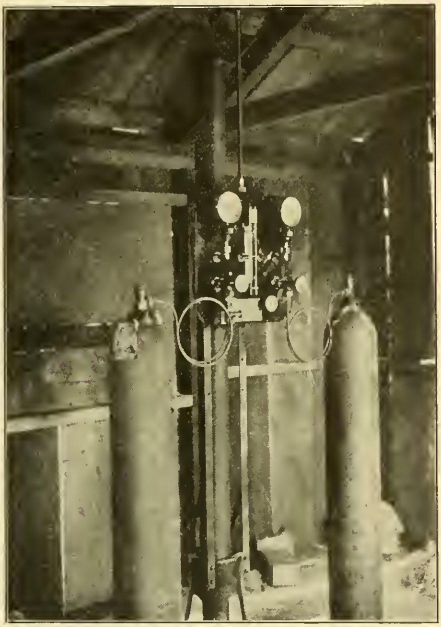

Fig. 27 Apparatus for Applying Chlorine Treatment to Water Supply

of sand would be discharged and the wells would soon fill up with sand. In order to avoid the expense and delay incident to removing the pumps and sand-bailing the wells, an air ejector was made which could be lowered into a well without disturbing the pump. By this means 50 ft. of sand was taken out in 3 hours, a large part of the time being consumed in putting down and removing the piping. The removal of such large quantities of sand soon caused the ground around the casing to cave, with resulting disturbance to the foundations of the building and equipment.

It became evident that the wells as they stood would never give satisfaction, and it was decided that their failure was due to the size of the gravel which had been placed in the annular space between the outside and inside casings. In the belief that a suitable material could be found which would keep the sand out and at the same time allow the water to flow through freely, it was decided to experiment with various mixtures of sand and gravel and different perforations for casings.

Flat test plates 8 in. by 12 in. were prepared, each having a different size of perforation. These were tested by placing them in a wooden frame box with trial mixtures of sand and gravel placed between the plates. Above the plates a quantity of the sand was placed that had been taken out of the wells, and water pressure applied. The flow of water was measured by meter and the pressures taken for different rates of flow. The result of these experiments was the selection of a naturally graded beach sand which had an effective size of 0.42 mm. and a uniformity coefficient of 2.18. It was determined that, with the use of this, sand plates could be used having a perforation of $^1/_{32}$ in. in width, and that the fine material from the wells would be held back even when the velocity through the perforations was as high as 0.75 ft. per sec. As the maximum velocity through the perforations under operating conditions would never exceed 0.5 ft. per second, it was considered safe to use this material.

As the wells, except No. 1, were not giving more than half the yield contemplated, it was decided to put down additional wells, making use of the data which resulted from the experiments. The contractor's price for the old wells was $7.50 per ft., and it appeared that new wells could be put down cheaper with the Exposition's force by using a hydraulic ejector instead of a well driller's standard equipment. The site chosen for the trial well was close to the main pipe line where water would be available at 175-lb. pressure. The hydraulic ejector or sand-pump was made with standard fittings, but had a machined brass throat piece. The well drilling rig and ejector are shown in the illustrations.

In starting, the bottom section was made up of a 5-ft.

Fig. 28 Filtration Plant. Filter House in Foreground

length of inner and outer casing, the inner casing being tapered to the diameter of the outer at the bottom and both riveted to a forged steel shoe. A hole was dug 5 ft. deep at which point water was encountered, and the bottom section set in place. The hydraulic ejector was placed inside and excavated the material down to the shoe. The first 15 ft. of casing went down of its own weight very rapidly, but for the balance of the distance it had to be forced down by means of the long lever shown. The maximum force applied was about five tons and the average rate of travel of the casing was 1 in. per min.

After 25 ft. of casing had been placed it was found that the well was badly out of line due to the removal of too much

material from one side. The casing was straightened up by putting a jet down one side and keeping a strain on the top of the casing by means of block and tackle. Guides were put on the ejector suction to keep it centrally located, and no further trouble was experienced with the casing getting out of line.

It required five days to complete the well to a depth of 60 ft. The outer casing used for this well was 22 in. in diameter, No. 12 gauge steel, with collar joints, each section being

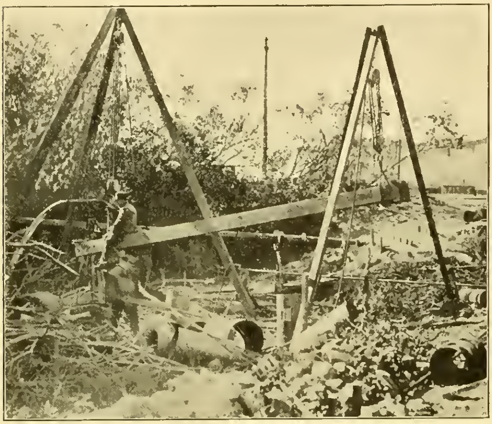

FIG. 29 RIG USED FOR DRILLING NO. 6 WELL

30 in. long, with perforations $^1/_{16}$ in. wide by $1\frac{3}{4}$ in. long. The inner casing was 16 in. in diameter, of similar construction, but with perforations $^1/_{32}$ in. wide. The area of the perforations was estimated at 0.0329 sq. ft. per running foot of pipe. Perforated casing was used throughout the depth of the well except for the bottom section and the upper five sections. The material used in the annular space between the inner and outer casings was that determined by experiment, and was put in place as the casing was lowered.

The well, on test, developed a capacity of 200 gal. per min. without discharging sand. Instead of drilling additional wells of this type, which would take time and involve additional pumping equipment, it was decided to reconstruct all of the other wells, except No. 1.

Efforts to remove the inside casing met with no success. Fortunately, the diameter of the deep well pumps was such as would allow the placing of a $13\frac{1}{2}$-in. casing inside the well. One of the wells was equipped with this size of perforated casing, and the space between it and the 16-in. casing was filled with the same grade material as that used in the No. 6 well. The installation of this casing was a comparatively simple matter and required about eight hours' work for an 80-ft. well. Under test the remodeled well operated continuously at a rate of 243 gal. per min., and no sand appeared in the discharge. The use of the additional casing and the sand increased the resistance to the flow of the water, and for the same yield the water surface had to be drawn down about 30 per cent lower than before. The rest of the wells were reconstructed in a similar way, and have all been brought up to capacity, without trouble from sand.

*Other Sources of Supply.* In October, 1913, three wells were sunk in the grounds which were of considerable use during the construction period, but owing to the questionable character of the water from a sanitary viewpoint these wells are no longer used, except for filling pools. Water is also taken from the Spring Valley Water Company for the Fisheries exhibits and to supply an occasional shortage.

*Amounts of Water Used.* Below is given a table showing the quantities of water used and the sources of supply from February 20 to July 31, inclusive:

| Month | Government water | Park water | Spring Valley water | Zone wells | Total (gal.) |
|---|---|---|---|---|---|
| Feb. 20-28...... | 723,937 | ...... | 226,775 | 204,000 | 1,337,500 |
| March...... | 733,523 | 347,290 | 106,990 | 34,703 | 1,228,965 |
| April........ | 724,270 | 591,760 | 29,593 | ...... | 1,345,617 |
| May......... | 612,887 | 564,636 | 19,116 | ...... | 1,205,636 |
| June......... | 473,057 | 1,057,730 | 54,910 | ...... | 1,585,694 |
| July......... | 398,460 | 1,060,094 | 138,696 | ...... | 1,597,250 |

It will be noted that the supply obtained from the Presidio fell far short of the estimated amount, 800,000 gal. per day, and that the Golden Gate Park supply has been increased materially over the assumed yield of 1,000,000 gal. per day.

FIG. 30 PERFORATED WELL CASING AND HYDRAULIC EJECTOR

Additional wells in the vicinity of the park are being developed which will probably contribute 500,000 gal. per day to care for the increased consumption to be expected in August and September, and offset a possible decrease in the yield of the old wells.

The maximum draft noted at any time shows that water was being used for short periods at the rate of 4,250,000 gal.

per day. On average week days 60 per cent of the total consumption is used between the hours of 8.00 a.m. and 4.00 p.m., and on Sundays (when there is no irrigation) about 47 per cent during these hours.

*Cost of Water.* The cost of water per 1000 gal. from the Golden Gate Park plant is 1.517 cents for pumping from the deep wells to the filters, 0.974 cents for filtering and treating with chlorine, and 3.935 cents for pumping to the Presidio reservoir, making a total cost of 6.426 cents per 1000 gal. delivered in storage. These costs cover operation and maintenance only. The water obtained from the Presidio is sold to the Exposition for 7½ cents per 1000 gal., while that taken from the Spring Valley Company averages 19½ cents per 1000 gal.

*Quality of Water.* Tests of the water from Golden Gate Park are made weekly by the Federal Laboratory, and in no instance has the treated water failed to meet the U. S. Government requirements for potable water. The following is a representative test:

Raw Water.......Gas in 10 c.c., colon types
count, 100 per c.c.
Effluent..........Gas in none of the specimens
Count, 12 per c.c.

*Construction Costs.* The filtration plant, including the pump houses for the main pumps and wells, together with the pipe line to the wells, cost $14,575. The cost of the first five wells was $3,075 and that of the No. 6 well $255. The cost of the sump was $14,979. The pumps, which included three 5-stage main pumps, one 4-in. vertical centrifugal sump pump, five 6-in. deep well pumps, and one 10-in. wash water pump, cost $4,962. The electrical equipment was rented. The cost of the pipe line from the pumping plant to the Presidio reservoir, and from the Presidio reservoir to the Exposition grounds, was $37,150. The total expenditure to develop a water supply and deliver it to the Exposition grounds was $77,000.

### TELEPHONE SYSTEM

One of the important activities of the Exposition is the operation of the telephone system within the grounds. An arrangement was made with the local telephone company, whereby the necessary equipment was rented to the Exposition and the latter installed the distribution system. An 18-position switchboard was installed in the Food Products building, at which point the trunk lines from the local company were terminated. In laying out the distribution system, the grounds were divided into sections and cables run to the approximate center of each. Cross connection boxes were installed at these points, from which feeder cables were run where required. The conduit system installed for the electric distribution was also used for the underground telephone cables.

In the buildings twisted pairs were run in rings along roof trusses or under the floors, while in the Zone district the subscribers were connected to a cable fastened to the fences in the rear of the concessions. In the States and Foreign sites cables were run to a few of the large buildings, and feeder cables from these points to other buildings. The underground distribution system required the installation of 47,700 ft. of cable (9,474,800 ft. of wire), of which 4300 ft. was 400-pair cable. Over 1,100,000 ft. of duplex wire was used in the overhead distribution.

With the view of facilitating the work of the Exposition's forces, private branch exchanges were installed in a number of the large departments. These exchanges had interconnecting lines in addition to direct lines to the main board and to one of the exchanges of the telephone company, the latter line being used only for outgoing calls. Fifteen attended pay stations with 100 booths were installed, one in each of the main buildings, three on the Zone and two at the entrances. These were later changed to non-attended stations as the income did not warrant the expense of attendants.

In addition to the foregoing, 53 telephones with coin collectors were installed at convenient points around the grounds. The Exposition installed 732 telephones for its own use and 1244 for the needs of its subscribers and pay stations. Subscribers are charged on the basis of the equipment required, the charge for a 1-party station being $6 per month. All services are metered and the rates for calls terminating within the City vary from 5 cents to 3½ cents each, depending upon the number used by the subscriber in any one month.

No one element of the organization contributed more to the successful opening of the Exposition on time than did the telephone department. The demands upon the telephone system around opening day were unprecedented, the number of calls handled per day reaching 49,500.

### CONCLUSION

The president of the Exposition, Mr. Chas. C. Moore, has been identified with many successful engineering enterprises, and when he undertook the responsibility of this great project he selected an engineer for the position of Director of Works. At previous expositions the Director of Works had always been an architect, and there was much criticism over the appointment of an engineer for this position, but the choice has been fully justified by the artistic results obtained and the completion of the Exposition on time and within the amount appropriated, a performance not usually associated with the construction of expositions or other monumental groups of buildings. There was some fear that with engineers in charge, whose efforts might be expected to be in the direction of keeping the costs within the allowances, there would be decisions which would seriously affect the aesthetic value of the various decorative features, and would stifle the zeal of the architects, sculptors and artists. But while the designers had their heads in the air, the engineers had their feet on the ground and many features were changed or eliminated to keep the expenditures within limits. These changes were made without friction, as the engineers were appreciative of the efforts of the architects, sculptors and artists and thereby secured their assistance toward the desired end.

The Exposition engineers have had an unusual opportunity not only to carry out their ideas in matters of construction, but to manage the operation of a great enterprise. Investigation will show, in this instance, the versatility of the engineer and his fitness by training and temperament to analyze a situation and to foresee difficulties and provide against them.

# MECHANICAL ENGINEERING AT THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION

BY G. W. DICKIE, SAN FRANCISCO, CAL.

Vice-President of the Society

THE Panama-Pacific International Exposition shows very clearly the changes during the past 22 years, or since the Columbian Exposition, particularly in mechanical engineering. At the lake front of the Chicago Exposition, there was a full-sized model of the first three battleships then building for the U. S. Navy. This model was built of bricks and concrete on piles, and in it the Navy Department had a very instructive exhibit. To-day the actual battleship, thus portrayed on Lake Michigan, lies in front of our Exposition as an illustration of a type now passing away, but with a twenty years' history to think of, of which the model on the lake shore gave no intimation.

*A striking feature of the mechanical engineering exhibits at the Panama-Pacific International Exposition is the entire absence of the steam engine.*

*In presenting his paper Mr. Dickie said that while the steam engine was advancing to the place it now occupies and many improvements were being made, the builder with something new was ready to show his best work at an exposition. This great prime mover has now reached maturity and will only take second place when the internal combustion engine has reached such a robust maturity as to enable it to do on a much smaller diet what our great steam engines are doing.*

The first thing that the mechanical engineer observes on entering the Palace of Machinery at the Panama-Pacific International Exposition is the entire absence of the steam engine. There is not a steam engine of any kind in operation, nor a steam boiler under steam. This is the first international exposition where the steam engine, as a prime mover, has been so conspicuous by its absence. On first thought the engineer might take this as evidence that the steam engine, after a century or more of development and a service to industry beyond reckoning, had suddenly reached a stage of innocuous desuetude and had ceased to rank as the greatest machine that the mechanical arts had produced. On second thought, however, he would have to admit that, of all the power developed by the combustion of fuel, more than 90 per cent is developed in the cylinders of steam engines or the rotors of steam turbines. His third thought would probably bring him to the conclusion that the steam engine, in all its varied forms, has reached that stage of development when no striking improvements can be looked for; in fact, the steam engine has in a sense reached its prime, and may be expected to continue doing a large proportion of the work rendered possible by the combustion of fuel, either liquid or solid. The fact that California is a great fuel oil producing state may be one reason why the steam engine forms no part of the machinery exhibits; yet the great bulk of California oil used for fuel is consumed under steam boilers.

There is quite a large display of gas engines in the Palace of Machinery, the Transportation Palace, and the Palace of Agriculture. These engines may be classed as:

(*a*) *Marine Engines, Otto type, constant volume class,* for distillate fuels such as gasoline and kerosene. In this class there are some fine exhibits, such as the Standard Gas Engine Company's exhibit, showing a good line of well designed and carefully finished engines from 100 h.p. down to small sizes. The Union gas engine, shown cut open to illustrate the movements of piston and valve gear, is a fine type of marine gas engine. The Gas Engine and Power Company and C. L. Seabury Company show interesting examples of engines.

The Van Blerck Motor Company exhibit some handsome engines of attractive design, which present new features. The Imperial Gas Engine Company have an attractive exhibit of substantial-looking engines; while others in the same class, such as the Buffalo Gasoline Motor Company, the Wisconsin Machinery and Manufacturing Company, the Loew-Victor Engine Company and the Waterman Marine Company are all well worthy of study. This type of marine gas engine is well represented at the Exposition.

(*b*) *Marine engines, Otto type, constant volume class,* with injection for heavy oils. Of this type there is but one example, that of August Mietz. It is a well designed and strongly built engine.

(*c*) *Marine Diesel oil engines.* In this class there are two exhibits—that of the New London Ship and Engine Company and that of the Fulton Manufacturing Company. The first-named works under a load of about 80 per cent of full power, the normal power being 200 horsepower. These engines illustrate the present state of the art in Diesel engines of moderate power.

(*d*) *Stationary engines, Otto type, constant volume class,* for distillate fuels such as gasoline and kerosene. Of this class a great variety is shown, suitable for a wide range of work. Mention might be made of the exhibit of the International Harvester Company, which shows these engines designed for all purposes to which motors can be applied on the farm and all other rural work. There is a rich field in this exhibit, which gives information as to the best way to hitch up a gas engine to almost any kind of work.

The Western Gas Engine Corporation exhibits stationary gas engines which present some features worthy of study. These engines have an unusually long stroke for gas engines, and were the first to introduce water into the carburetor. The valve gear is very simple, with free-moving parts operated by a rod from a single eccentric.

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The Doak Gas Engine Company and the Bessemer Gas Engine Company show some good work under this class. The Standard Gas Engine Company's exhibit is also well worthy of attention.

(*e*) *Stationary engines, Otto type, constant volume class,* with injection for heavy oils. Under this type some very good exhibits are shown, notably those by August Mietz and the Bessemer Gas Engine Company.

(*f*) *Stationary engines, Otto type, constant volume class,* for gaseous fuels. In this class there are two exhibitors, the Standard Gas Engine Company and the Western Gas Engine Corporation. As the arrangements of valve gear, etc., of these engines are quite different in design and function, they offer a good opportunity for comparison.

(*g*) *Stationary Diesel oil engines.* In this class there are two exhibitors, the Busch-Sulzer Bros. Diesel Engine Company and the McIntosh and Seymour Corporation. Both show fine examples of vertical engines of 500 h.p. each and both illustrate the best that these makers produce. Each engine is operating with Star distillate, which is probably the nearest to California crude oil with which it is safe to work these engines.

In the special types of gas engines or motors shown in the Transportation building, a large and varied display illustrating their application to automobiles, motor trucks and motor cycles, gives ample opportunity for study in this interesting field. The beautiful workmanship on many of these show the taste and skill that has been brought to bear upon the development of this immense industry.

California is not only rich in liquid fuel, making it an ideal home for the internal combustion engine, but the whole Pacific Coast is a land of liquid power, ready to be used without the necessity of burning anything to produce it. The winter snows on the high Sierras and other mountain ranges forming the eastern boundary of the Pacific slope are the source of this vast accumulation of stored-up energy, which, in the past thirty years or so, has been more and more converted into electrical energy and carried for hundreds of miles to the points where it is needed, to operate factories and street cars, light cities, warm houses and cook food. It is not surprising, therefore, that the most impressive exhibit in the Machinery Palace should be that of the Pelton Water Wheel Company. The writer felt his inability to do justice to this splendid example and asked help from W. A. Doble, chief engineer of the Pelton Water Wheel Company and the designer of much of the display made, who kindly furnished a description from which the following is taken:

It being impossible to secure water, either in sufficient quantity or under pressure desirable for driving hydraulic prime movers, an effective combination of turbine pumps, drawing water from a common sump, and discharging, through control devices and pipe lines of the types customarily employed in hydroelectric practice, into water wheels of both the tangential and turbine types using the sump as a tail race, has been worked out.

The operating division consists of two sections:

*a* A high head pumping project combined with a high head hydroelectric development where water economy is important, and employing tangential water wheels.

*b* A deep well pumping project combined with a medium head hydroelectric development, employing mixed flow turbines.

The high head pumping plant consists of a Pelton-Doble turbine pump, driven through a flexible coupling and herringbone speed-increasing gears by an internal combustion engine. The high speed shaft of these gears turns at 1800 r.p.m., the efficiency of transmission at full rated load of 150 h.p. being in excess of 98 per cent.

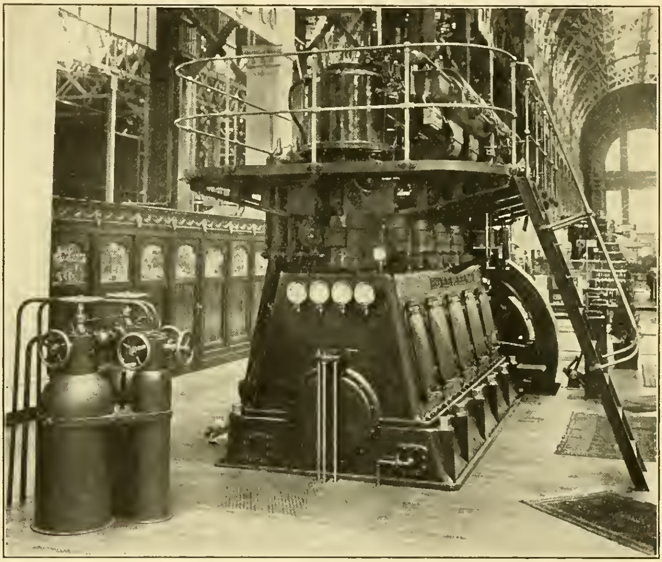


Fig. 1 500-h.p. Diesel Engine Exhibited by Busch-Sulzer Bros. Diesel Engine Co.

The engine is a 6-cylinder vertical type, developing 180 h.p. at 350 r.p.m. It uses heavy oil up to 18 deg. Beaumé for fuel and operates on the 4-stroke cycle with maximum compression not exceeding 450 lb. per sq. in. No ignition difficulties are experienced with this low compression.

The pump is a single stage uni-diffusion type, having a capacity of 1100 gal. per min. against a head of 300 ft. The discharge line, after passing through an 8- and 6-in. venturi ring, connects to a Pelton-Doble tangential unit, rated at 100 h.p. under 300 ft. head and operating at 300 r.p.m. This unit is of the single overhung, two-bearing type, with the armature of a 75-kw., 250-volt engine-type direct current generator carried between the bearings, and a flywheel overhung on the shaft end opposite the tangential runner.

Water from the high-pressure pump is applied through a needle nozzle, governing being accomplished by an oil pressure type governor mounted on the nozzle casting, and actuating the needle directly through suitable link and rock-shaft connections. An auxiliary relief needle nozzle avoids

excessive pressure rise in the pipe line and minimizes water waste during governing cycle. The needle of this nozzle is connected to a spring-controlled oil cylinder, known as the cascade cylinder. Ports, adjustable from the outside of the cylinder, determine the time element of piston travel. The same link and rockshaft system that actuates the main needle nozzle is connected to the piston of the cascade cylinder, the relative motion (and thus the nozzle area) being equal and opposite in direction when the time element of the cascade cylinder is zero. With this setting, the auxiliary nozzle merely acts as a synchronous bypass, and the water quantity is constant. Where water economy is of importance, the time element of the cascade cylinder is so adjusted that a rate of closing of the main needle which does not raise the surge pressure to a dangerous point will not open the auxiliary needle. Higher closing rate opens the auxiliary needle, which is then returned to closed position by the compression springs of the cylinder mounting at a rate that will not cause dangerous surge pressures. This is the position of maximum economy.

The deep well pumping plant consists of a Pelton-Doble bore-well type turbine pump, with a capacity of 4500 gal. per min. against a head of 60 ft. and driven at 1760 r.p.m. by a vertical motor mounted on the pump pedestal. The maximum diameter of the pump is $22\frac{1}{2}$ in., permitting its easy entrance into a 24-in. bored well.

The discharge orifice has a diameter of 14 in., and has, bolted directly to it, a riveted steel pipe line which leads to a Pelton-Francis turbine. A venturi ring, 18 in. in diameter, is set in this line. This unit operates under a head of 50 ft. and develops 50 h.p. at 1400 r.p.m., an unusually high specific speed.

The entire operating division is arranged for laboratory investigations, and more than 800 tests have been conducted by independent engineers and the staff of the Pelton Water Wheel Company. During the autumn semester of the local universities, 1915, additional tests will be conducted by senior students of the engineering departments.

The central feature of the entire exhibit is a Pelton-Doble single, overhung-runner, single-discharge turbine, rated at 20,000 h.p. under 500 ft. head, at 360 r.p.m. The entrance valve, casing, draft tube and governor are assembled complete; the runner, of bronze with steel hub and forged wearing rings, and fitted with leakage evacuators, is displayed on a separate pedestal. The main valve, of the butterfly type, is 66 in. internal diameter, with body of annealed cast steel.

Two runners, each rated at 10,000 h.p. under 1350 ft. head at 360 r.p.m., are displayed. These are of the chain connected type, with ellipsoidal cast steel buckets. The jets for these units are 7 in. diameter, and are projected from deflecting needle nozzles with motor operated manual controlled needles and governor controlled deflection. One of these nozzles, assembled complete with motor, and three needles, pedestal mounted, are displayed. A single bucket of the chain connected type, taken from a wheel rated at 14,000 h.p. under 870 ft. head at 200 r.p.m., is also displayed. A number of water motors of standard and special design complete the tangential section.

In the governor section are displayed a group of self-contained oil pressure type governors, of 5000 ft.-lb. drawbar effort, and, in conjunction with a standard mounted tangential unit, an enclosed type of oil pressure governor having a drawbar effort of 80 lb.

The exhibits of machine tools are not very numerous and, outside of two very notable exhibits, there is nothing in this

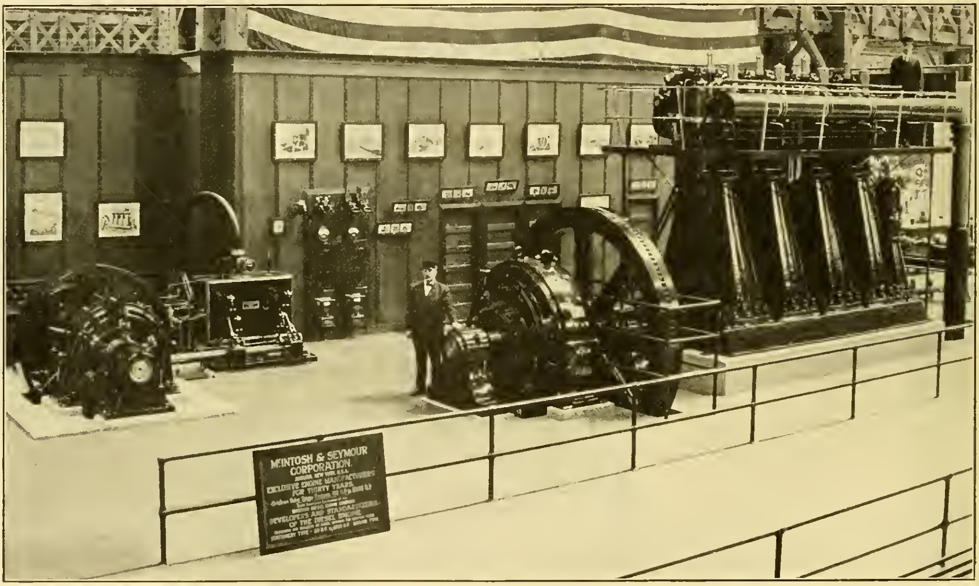



Fig. 2 500-h.p. Diesel Engine Exhibited by McIntosh and Seymour Corporation

line that requires the attention and study of the mechanical engineer who has a fair knowledge of the modern machine tool. Before examining the machine tools it would be well to inspect the exhibit of the Tinius Olsen Testing Machine Company as the records produced by such machines form the foundation work for all modern machine tool design. The mechanical engineer finds in this exhibit, which is probably the best in its class that has ever been exhibited by one maker, much food for thought and many admirable ideas in design.

Testing machines and apparatus for engineering research and development may be arranged in two main groups: *a* Apparatus and machines for testing structural materials in the form of specimens, as well as the testing of complete designs and structures. *b* Apparatus and machines for testing the materials from which tools are to be made, as well as testing the finished tools.

In the United States prior to 1870, very little progress was made in apparatus for ascertaining the actual strength of materials. One device may be mentioned as used by the U. S. Board of Ordnance for testing the cast iron used in gun making. We know also of one hydraulic press used by Captain Eads for testing the members of the first bridge over the Mississippi River. About 1870, the U. S. Government established the Bureau of Boiler Inspection in connection with the U. S. Steamboat Inspection Service. This bureau formulated rules which required that all boiler plates should be tested by having a cupon from each plate subjected to tensile strain for determining the breaking strain, as well as the yielding point or elastic limit, also the reduction of area at the breaking point and the elongation between two points. Hence came the inquiry for and the development of the commercial testing machine.

The first machine of 40,000 lb. capacity was designed and built by Mr. Olsen for boiler plate manufacturers. Soon after, about 1870, he built ten such machines for the different branches of the Boiler Inspection Service. Following this development, the technical and engineering schools began to install such machinery. One of the first—if not the very first—was bought from Mr. Olsen by Dr. R. H. Thurston for the Stevens Institute of Technology, Hoboken, N. J.

As time passed the testing machine was changed in design and improved and put to more constant and varied use by all manufacturers of structural materials, as well as large users, and also in technical schools, where its use developed laboratories with apparatus of larger and more diversified forms and functions to include investigation of the more varied character and direction of stress to which materials are subjected in modern design .

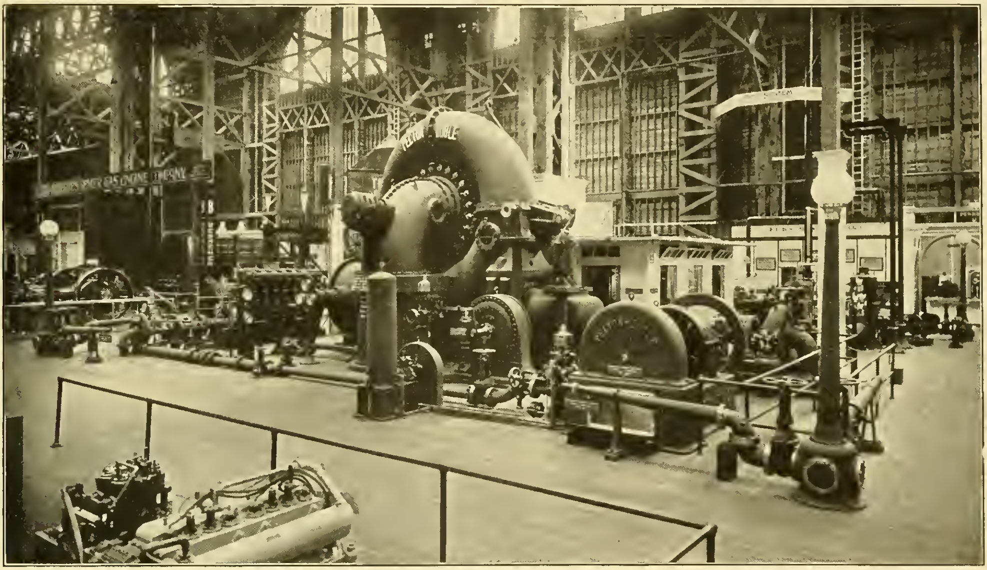


Fig. 3 Pelton Water Wheel Co.'s Exhibit, Showing 20,000-h.p. Pelton-Doble Turbine

In group *b* are classed what are termed efficiency testing machines. These machines are of more recent development, although a simple machine of this class was shown at the Centennial Exposition, 1876, in a file manufacturer's exhibit; it was probably made by him to demonstrate the most efficient method of file cutting, as well as the most reliable material for file making and the best method of tempering. Nothing more was publicly shown in this line until a few years ago, when Edward Herbert of Manchester, England, placed on the market his file testing machine and a little later his machine for testing the efficiency of tool steels, especially modern high speed steels. A few of these machines are in use in this country. These two English machines are shown in Mr. Olsen's exhibit at the Exposition.

A few years ago, Mr. Olsen was called upon to design a machine for testing the efficiency of drills, taps and dies. About two years ago this was worked into a practical machine for the Philadelphia Navy Yard and has proved satisfactory, filling all the requirements for this purpose. Later,

by additional attachments, this machine has been perfected so as to make a universal tool as well as a tool steel testing machine. This machine in its newest form is shown in the Olsen exhibit; it will test tool steel, lathe and planer tools, milling cutters, drills, taps, dies, rimers, files, and hack saws, thus forming a practical efficiency testing machine for determining the quality of most tools as well as the most effective way to make and use them.

The Olsen exhibit is well worth a careful study by the mechanical engineer. Mr. Olsen himself is usually at the exhibit and he looks upon this fascinating collection of testing machines as his own children. As he knows all their little weaknesses as well as their good qualities, an hour's conversation with him is a liberal education in this subject. Here the observer will find the universal testing machine and instruments, spring testing apparatus, cement, concrete and road material testing machinery; cloth, yarn, paper, rubber and leather testing machines; oil testing machines, transverse testing machines, and special testing machines including im-

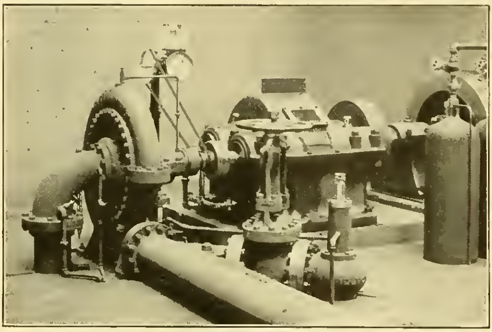


Fig. 4 Centrifugal Pump and High Speed Transmission. Pelton Water Wheel Co.'s Exhibit

pact, indentation, vibration, bending, hardness, endurance, torsion, and efficiency testing.

It is unfortunate that some of the largest machine tool makers of this country who had reserved a large amount of space in the Machinery Palace should have withdrawn from participation in the Exposition on the outbreak of war in Europe under the impression that the Exposition could not be a success under the conditions. This is to be regretted, as it leaves a gap in a very important part of the machinery department that the mechanical engineer will not fail to observe. Nevertheless, there are some notable exceptions whose presence makes this condition much less felt than it would otherwise have been.

Among these exceptions the engineer will not fail to notice the splendid collection of both automatic and semi-automatic tools exhibited by the Warner and Swasey Company. This company shows ten tools, several of them being of new design; the tools are all shown in operation and are attracting the favorable criticism of our best mechanics. Their new universal turret lathes are powerful tools and have some remarkable features. Because of their superior strength and rigidity and the fact that each carriage with its independent feeds is able to operate simultaneously, the lathes are enabled to produce a very large amount of work. They have equal facilities for both bar and chucking work. They have geared heads with splash lubrication. As many as eleven cutters may be used in the turrets and carriages of these lathes, all cutting at the same time and in one set up.

The other tools exhibited by this company belong to their line of screw machines and plain turret lathes which are so well known as the product of the Warner and Swasey Co. and are all characterized by the same scientific design and careful workmanship. The automatic boring and tapping machine used by all the large manufacturers of steam and water fittings for boring, facing and threading their outlets, valves, and joints is also shown in operation. This machine finishes unions as fast as the operator can put them in the chuck and an average of 350 one-inch unions are turned out in a day of nine hours by this machine.

Another exhibit that has given character to the display of machine tools at the Exposition is that of the Morton Manufacturing Co. This is an exhibit of draw-cut shapers, traveling head planers and key-seating machines. The draw-cut type has been developed by this company and lends itself to heavy cutting to a remarkable degree. The whole stress of cutting draws the work solidly and directly against the face of the main casting of the machine and eliminates the stresses from the table rail or the upper bolts holding the table as in the usual type of shaper. The tool arm or ram is under tensile stress in cutting, which tends to reduce or eliminate vibration; when the ram or arm is in compression, the heavier the cut the greater the danger of vibration. One feature of this type of shaper or planer is the facility it offers of shaping to lines, as the latter are on the outside in view of the operator and are not broken or destroyed by the tool as it leaves the work. The tool beginning its work on the face next the operator, the lines on that face can be worked to very accurately as they are not broken or destroyed until cut out by the tool itself. This feature is of great value to the operator as well as the owner of the tool. There is an adjustable back bearing which forms a stop or abutment to the end of the vise when planing parallel with the jaws. With this stop it is only necessary to clamp the work sufficient to hold it as the thrust of the cut comes against the back bearer or stop. As the drawing or pulling cut overcomes vibration, it is possible to make forming tools to be used in these machines at a moderate cost. Rounding tools, either concave or convex, can be made of various radii for producing correct curves in finishing parts of connecting rods, etc. Cutters can also be used for machining parallel openings cutting down both sides at once. Being the originators of the draw-cut principle as applied to this class of machines, the makers have consistently followed up every indication offered by their extended use leading to further improvement in design and operating function.

In the collective exhibit of Fred. Ward and Sons there are shown some very good machine tools, notably those by the American Tool Works. The engine lathes shown are well constructed modern tools with easily adjusted feeds and with speeds especially adapted and designed for electric drive. They are capable of caring for the service demanded by the use of high-speed tool steels and, as demonstrated at work, are good machines for modern manufacturing or general shop use. A planer and a shaper of good design and strongly built are also shown. The radial drilling machines shown by the same company are of good design and well built; they are also well balanced, as shown by the absence of vibration

when working at high speeds; the speed changes are readily made and the tapping attachment is very good.

Gould and Eberhart exhibit a shaper of excellent design and workmanship adapted for heavy work. The arrangement for changing the length and position of stroke is very good. The motor that drives it has two speeds brought about by sliding the armature through the field of the motor which reduces the number of change wheels required in the gear box. The same firm shows a special gear cutter which cuts two blanks at the same time; this is a strong, well built machine with several features that should be of interest.

In the extensive exhibit of products made by the Crane Co. is a motor-driven pipe-threading machine having two unusual attachments—a quick centering rear chuck and compressed air cutting-off tools. The whole machine is well designed and strongly constructed, and on account of the two unusual devices referred to is of interest to those specializing in pipe work and fittings. This machine is made by the Crane Co. for its own establishments.

The Landis Tool Co. exhibits grinding machines of both universal and special application. The several machines are of high-class design, massive in character and fitted to produce a wide range of work. The excellent quality of their work shows the care displayed in the building of the machines and the arrangement of the exhibit shows the wide and varied application of these machines in the mechanic arts.

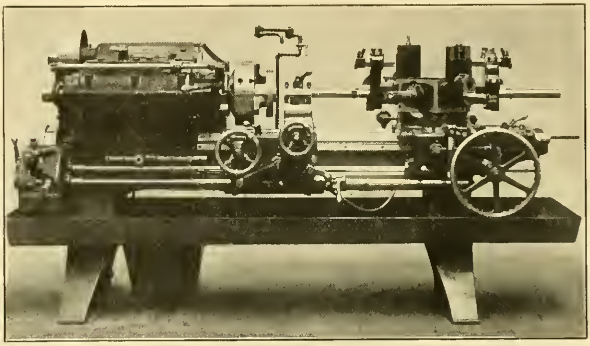


Fig. 6 Universal Hollow Hexagon Turret Lathe Exhibited by Warner and Swasey Co.

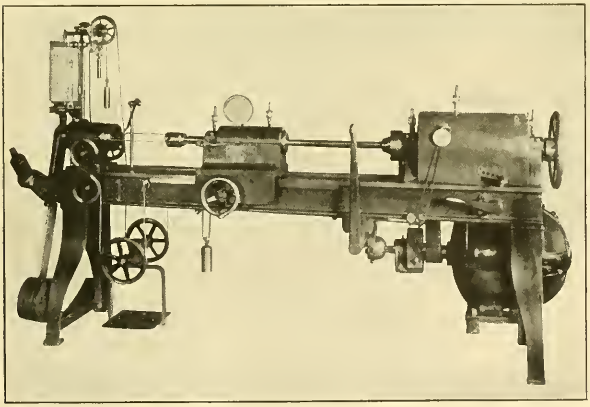


Fig. 5 Universal Efficiency Testing Machine. Tinius Olsen Testing Machine Co.'s Exhibit

There are a number of other metal cutting and shaping machines that attract attention in the Palace of Machinery and in the other buildings of this great Exposition; the engineer will discover them in places where he would never think of looking for such things, but on close inspection he will find that they are in some way connected with other things that belong in the place where be finds them. While the display of machine tools is, for reasons already explained, by no means complete, there is enough to dispel any anxiety in regard to the ability of the tool makers to meet all the requirements of the engineer for tools to produce anything within the compass of mechanics.

California being an extensive fruit growing state, much of that product must be shipped to other states and foreign countries either in wooden boxes or in tin cans and the machinery required to make these containers is of great interest. At the Exposition this class of machinery is well represented and merits a careful study by those interested in automatic machinery.

The William S. Doig Co. are pioneers in the manufacture of box making machines. Their exhibit contains a complete set of machines of wide range and application for labor saving in the making of boxes. A clever device shown in this exhibit is a machine for fastening two or more pieces of wood together edge to edge. On this machine a number of reels contain corrugated steel ribbons sharp on one edge; if the pieces to be fastened together are long enough to require, say, four fastenings then there are four reels. The strips to be fastened together are drawn in at one end and discharged at the other. The corrugated ribbons are drawn in at one side at right angles to the seam and are cut off in lengths of about $1\frac{1}{2}$ in. and driven into the wood across the seam making a solid joint. This machinery enables strips of any width to be combined to make sides and ends, bottoms and tops of boxes, and saves much lumber that would otherwise be wasted. One machine with two boys will work up 4000 to 5000 feet of lumber in a day.

At the George D. Parker exhibit two box making machines are shown, both new in design. One of these, the orange box machine, has now obtained a wide use in California. It is automatic and makes an orange box in four movements. Another machine which has just been perfected after seven years' experimenting is shown. This completes a box at one stroke or revolution. The ends and sides are pushed up from below by a ram to the proper place while the bottom is pushed in from the back of the machine; the nailing mechanism acts simultaneously on the bottom and sides, while a ram pushes the finished box out of the way of the material

coming up for the next box. This universal machine is highly ingenious in design, entirely automatic in operation, of large capacity and has great economic value.

At the Max Ams Machine Co.'s exhibit is a complete set of can making machinery, arranged in the order usually occupied in a large can making establishment and being a complete outfit for making sanitary and open-top cans. Much ingenuity and good workmanship is displayed in this company's exhibit.

In the E. W. Bliss Co.'s exhibit is a very complete operating exhibit of power metal working machinery illustrative of the high degree of perfection to which this class of machinery has attained. The sanitary can making equipment is almost entirely automatic. The design of the different presses and carriers shows great mechanical ability; the automatic actions are perfect in operation, displaying fine construction and accurate workmanship. The individual presses with semi-automatic attachments for the manufacture of various types of metal boxes and cans and the automatic threading machines show the same fine workmanship and precision of operation of the automatic working parts. To this equipment is attached an ingenious and effective can testing apparatus which charges each can with 40 lb. air pressure and passes it under water, immediately showing a bubble if there is a leak; this testing is continuous and its speed equals that of the machine delivering the cans.

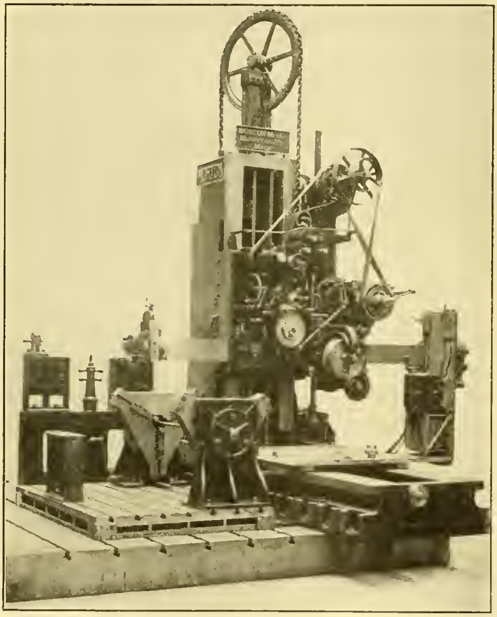


Fig. 7 Cylinder Planer Exhibited by Morton Mfg. Co.

Also in the line of automatic machines, at the U. S. Army Ordnance Department exhibit is found a set of cartridge-making machines in operation; this comprises a very interesting set of machines that show the result of the long process of perfecting required in machines for delicate operations. To such an extent has this perfecting been carried out that some of these machines are arranged to remind the operator of his omission should he neglect to do his part. This demonstration is very interesting and instructive.

At the exhibit of the Carborundum Co. in the Palace of Machinery is shown an exceedingly high class exhibit of unusual educational value, extensive application of product, and instructive demonstration. The product of this company has revolutionized certain methods of manufacture, lowered costs and increased output. The application of the cutting wheels, cylinders, and discs extends from the cutting of the hardest crystals to the buffing of leather and cloth.

Illustrative of cutting metals by a flame cutter there are several exhibits of the oxy-acetylene cutting and welding equipments. The best exhibit is that of the Davis-Bournonville Co. in the Palace of Manufacturers as it shows a complete oxy-acetylene equipment including the apparatus for producing oxygen.

The fact that the Pacific Coast is a good market for saws, especially wood cutting saws, brought some good exhibits of that class of cutting tool to the Exposition, the most notable being the exhibit of Henry Disston and Sons, Inc. This firm shows a splendid collection of saws both for wood and metal cutting. The new forms of metal cutting saws with inserted teeth show the most advanced practice, the teeth being made of the newest grade of tool steel for high speed cutting in hard metals.

As he works his way through the Palace of Machinery, the mechanical engineer, if he be at all interested in the shaping of sheet metal, will stand for a while at the exhibit of the Dreis and Krump Manufacturing Co., who show a line of very well thought out brakes for bending metal plates. Three machines are shown, two being for light work, such as cornices or pilasters, adapted to all classes of straight line work, producing sheet metal boxes with right angle corners with great rapidity, and one for heavy steel plate, powerful in character and capable of bending to sharp angles plates $\frac{3}{8}$ in. thick and 12 ft. in length, this latter is a very original machine with well designed and strongly constructed steel working parts.

The Geometric Tool Co. in the Palace of Varied Industries exhibits tools for cutting external and internal threads, interesting on account of the fine and accurate workmanship and ingenious design displayed. The head for external threads opens automatically as soon as the length of thread for which it is set has been cut. For internal threads, the taps automatically collapse at the points for which they have been set. In each case, when the thread is finished the chasers do not return over the threads on the reversing of the tool. These tools can be used in any screw machine or turret lathe and show a decided advance in tools of everyday use.

The exhibit of the Hydraulic Press Manufacturing Co. is an e tensive display of presses including pumps, valves, etc., for the manufacture of cider, olive oil, etc., and for filtering the same. There are shown also presses for bending or straightening metal bars, pressing car wheels on to axles and other similar lines of work.

Among small tools are those shown by the Henry G. Thompson and Sons Co. in the Palace of Manufactures, whose exhibit consists of an interesting line of hack, power, and jig saws for cutting metals, and also some very clever tool holders.

The requirements of modern civilization have opened up many and varied fields for the engineer to cultivate for the good of humanity; this is very forcefully illustrated in the matter of food preservation and today there are large establishments devoted to the production of refrigerating machinery. There are four exhibits of refrigerating machinery at the Exposition that merit attention. Two of these are in the Palace of Food Products, one in the Horticultural Palace, and one in the Manufactures building.

The Larsen Ice Machine Co. has a very fine and interesting exhibit consisting of a complete plant for the freezing, storing, and hardening of ice cream, the daily capacity of the plant shown being 400 gal. The freezer cylinders and agitator are of German silver made without a seam, insuring perfect cleanliness.

Near this exhibit is that of the York Manufacturing Co., which is an exhibit of a complete refrigerating plant in operation, keeping cold several chambers throughout the building.

The exhibit of a complete refrigerating plant by the Vulcan Iron Works will be found very interesting. The refrigerating chambers are a part of the exhibit and, being of glass, show the splendid condition of the foods inside, there being no sign of dampness either on the inside of the glass insulation or on the contained meats, butter, cheese, etc.

The remaining exhibit of refrigerating machinery is by the Automatic Refrigerating Co. and is the only complete automatically controlled refrigerating plant on exhibition. The automatic control is a decided step in advance on new ground; it automatically stops the machine when the temperature in the refrigerator chamber reaches a point one degree below the temperature for which the machine is set and starts it again when the temperature is one degree above that point.

There are many other engineering exhibits in the Palaces of Machinery, Transportation, and Manufactures. Among those worthy of mention are the Dodge Manufacturing Co.'s exhibit of general power transmission machinery and accessories, which includes a good example of the Dodge system of rope drives. There is also the Zimer vibrating screen, an ingenious combination of reciprocating and tossing action by which the material is screened and conveyed at the same time, designed especially for moving and segregating hot ores, bolts, rivets, ashes, slag, etc.

The exhibit of lubricating oils made by the Union Oil Co. of California shows real achievement in petroleum technology and the company deserves great credit for its scientific development of lubricants from California crude oils. As petroleum specialists, this company has succeeded in developing oils suitable for all classes of lubrication, as has also the Standard Oil Co., which has shown great skill in the treatment of oils for the many and varied uses to which its product is applied.

To the engineer interested in the distribution systems of water works, the exhibit of the A. P. Smith Manufacturing Co. is one of great interest; this is a collection of water gate valves, fire hydrants, water works machines and appliances. The most interesting feature is the exhibit of appliances used for placing a gate valve into a line of main pipe while the latter is under pressure.

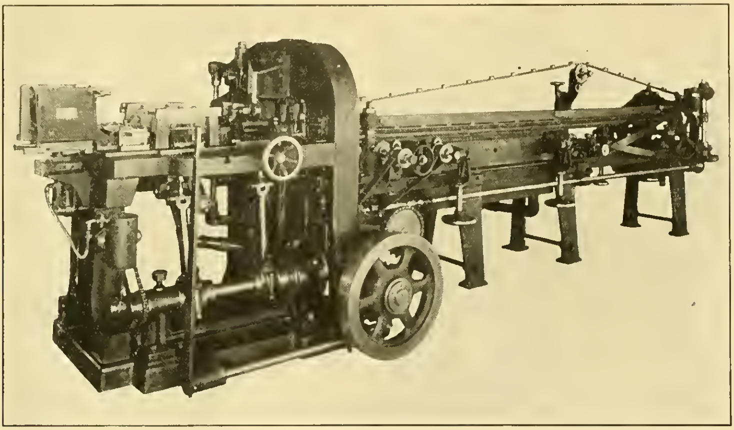


Fig. 8 E. W. Bliss Co.'s Automatic Can Body Maker. Capacity 150 Cans per Minute

The economical handling of materials in the shop is illustrated in the working exhibit of the Shephard Electric Crane and Hoist Co. This consists of electric power cranes and hoists for use from one or two overhead supports; also an electric winch, monorail track, and electric controllers and switches especially adapted for hoisting apparatus.

The General Electric Co. shows a complete self-propelled electric truck on which is mounted an electric crane; this is demonstrated in operation and is an attractive and instructive exhibit.

The correct measurement of the quantities of liquids during their transmission through pipes has always been an interesting problem, and at the Exposition are two exhibits, that of the Neptune Meter Co. and that of the National Meter Co., illustrating apparatus for this purpose.

The Neptune Meter Co. shows a very complete and well arranged collection of various types of meters designed to measure and record different liquids in various units and quantities.

A special form of the compound meter known as the "Protectus" is shown; this is of new design and contains in combination a disc meter, a turbine meter, and a "Control Orifice Tube" with an automatic check valve at the delivery end of the tube. This valve is operated by excess pressure in the tube when the flow from the discharge pipe of the compound meter exceeds 50 per cent of the capacity of the disc meter. The opening of the check valve acts mechanically to close the outlet valve of the disc meter and stop its action and open wide the passage through the orifice tube and the turbine meter. The turbine meter is proportioned to measure 25 per cent of the flow through the orifice tube and to register the combined flow of itself and the orifice tube. A special adaptation of the disc meter is shown in an apparatus for measuring and recording a predetermined quantity of liquid and automatically stopping the meter and the flow when that quantity has passed the meter.

Among others a meter of the turbine type named "Gem"

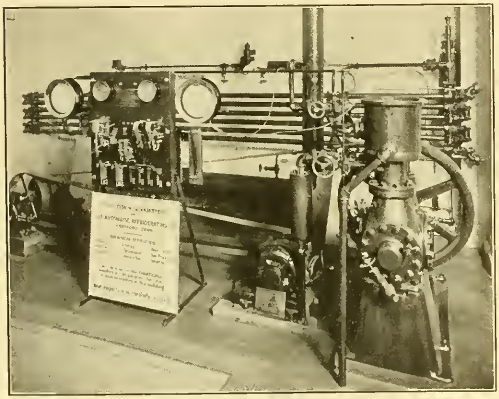


FIG. 9 REFRIGERATING PLANT EXHIBITED BY THE AUTOMATIC REFRIGERATING CO.

is shown; this is adapted only to the measurement of large and rapid flows and is used either alone or in combination with one of the oscillating piston type called "Empire," to form the "Empire Compound." In this arrangement the passage through the "Empire" is always open while that through the "Gem" is controlled by an automatic differential check valve which opens under the difference of pressure produced by a large flow through the "Empire" meter. Of special interest is an apparatus having the name of "Premier" to be placed in 30-in. water mains. It consists of one large and one small venturi tube in parallel relation.

Both these exhibits of meters are of great interest to the engineering profession, which is sufficient excuse for giving a somewhat lengthy description of them.

At the Exposition there is a large amount of pumping machinery for all the varied purposes for which pumps are used. The Luitwieler Pumping Engine Co. has an exhibit consisting of Luitwieler pumps of two different types adapted to surface, deep well and hydraulic service. The special feature is the method of driving. In place of the usual crank shaft operating through connecting rods there are eccentric or heart-shaped cams with the face of the cam working on rollers to produce the motion for the pump ram or bracket. The motion transmitted to two or more pump rods may be so arranged as to give a non-pulsating constant discharge of water or other liquid. The surfaces of the cams are hardened as well as the rollers; they are both generous in size and little wear need take place.

The Layne and Bowler Corporation exhibits a turbine pump especially adapted to deep wells. Its special feature lies in the pump chamber being suspended from its upper end, as are the rotating parts. The shaft rotates inside a central pipe in which it has bearings at intervals, lubricated with oil or clear water injected at the top of the pipe; the shaft bearings are thus protected from contact with dirty water. The rotating parts are carried on roller bearings at the upper end of the shaft, and for heavy pressures these are supplemented by oil pressure applied between one or more pairs of discs.

The Krogh Manufacturing Company exhibits a variety of centrifugal, turbine, and plunger pumps for various uses, which are of good design. Among these are a vertical centrifugal mine sinking pump, cornish pumps, jack head pumps, multi-stage mine station pumps, single-stage motor driven horizontal centrifugal pumps, multi-stage high pressure turbine pumps, and a long double-suction centrifugal pump with a capacity of 30,000 gal. per minute. Each rotating disc fixed to the shaft is enclosed within a close fitting bronze ring which has free lateral movement. This is a well-designed pump marking progress in a class of machinery that has been in a stationary condition for some time past.

The American Well Works has an exhibit consisting of a large variety of centrifugal, turbine, and deep well plunger pumps, of good design.

Closely connected with pumps are pipes, valves, and fittings. These are found in great variety and of all dimensions in the Crane Co.'s exhibit, some of the main features of which are: One 72-in. wedge water gate in operation worked by a hydraulic lift and weighing 56,000 lb.; one 36-in. wedge water gate in operation worked by a motor; a complete line of steel water gates from 2 in. to 18 in.

There are many other exhibits that should have been mentioned if space permitted. In the Palace of Mines there is much that is interesting and new. This branch of engineering coupled with the advance in chemistry and metallurgy has made great progress in recent years and much of that progress can be traced in the exhibits in this building.

In the Palace of Transportation, the progress in that field of engineering can be traced through all its stages. In one corner is found an interesting old pioneer with the wagon in which he crossed the continent 65 years ago and from that point of beginning can be followed the progress in transportation upon to the present day, when 60 miles an hour can be made on our improved highways with almost the comfort of a railroad coach.

From the great exhibit of the Westinghouse Co. in the Palace of Transportation as a center, wherever one turns new wonders of mechanical genius continually arrest attention, and the skill that has conquered the land, the sea, and the air, all help to raise the engineer's estimate of the worth and dignity of the profession to which he belongs.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

Among the problems of power generation which still await solution is that of the gas turbine. Holzwarth, it is true, built a gas turbine rated at over 1000 h.p. more than three years ago, but it has never been placed on the market commercially and its efficiency as claimed by Professor Stodola appears to be quite low. Of late, papers have stated that a large amount of work has been done on the gas turbine by the Brown-Boveri Company, which is said to have organized a special department for this work which is there carried on with a considerable amount of secrecy. Nothing concerning it has been reported in the regular trade papers, but from the newspaper reports it appears that the Brown-Boveri Company, like many other experimenters with gas turbines, had considerable trouble on account of the rapid wear of the turbine blades. In this month's Survey, an abstract is given of an article by Alfred Walter, on Gas Turbines, in which the author makes several statements of considerable interest. In the first place, he claims that the explosion type of gas turbine is limited in its possible development and that it is the constant pressure type that is likely to give the final solution. Further, he expresses a belief that the gas turbine will finally be developed along lines somewhat similar to those of the steam turbine, viz., that multiple wheels will be adopted for the gas turbine also. As a continuous process of flow does not appear feasible practically in the case of a gas turbine, the writer recommends a process composed of elements occupying long periods of time. He describes a design of gas turbine on rather novel lines, in which there are three chambers, two of which are working continually, while the third is in the state of cooling.

### This Month's Articles

The Diesel engine propelled ship, *Pacific,* with its power plant and electrical equipment, is described. The article contains some data showing the growing adoption of the Diesel engines for ocean ship propulsion.

The next article compares the Diesel engine with the suction producer gas engine for ship propulsion, and shows that at certain prices for anthracite and oil, the suction producer gas engine may prove to be more economical than the Diesel engine.

F. Hoffmann presents data on the maximum contents of hydrocarbons in producer gas and among other things, gives a table showing the average output of gas from the most important German types of gas coals.

P. Ludwik describes an investigation into the properties of metals at higher temperatures; for steel and wrought iron up to 1300 deg. cent. This article is of interest, as comparatively little information has been published on the variation of strength of metals in these regions of temperature.

A communication from the Institution for Testing Materials of the Royal Technical High School at Stuttgart, is devoted to the investigation of the brittleness of wrought iron, produced by the heating of compressed materials. It is of particular interest to boiler engineers, as it affects the strength of the notched boiler plates. (The notching may come from knocking off scale.)

The question of the saving of fuel on locomotives by the use of feed water preheating and the differences in effectiveness of various types of preheaters, as well as the field of application for preheaters, is carefully considered in an article abstracted from a German periodical. In the same section are described locomotive superheaters using smoke tubes of small diameter.

Interesting statistical information on the increase in safety of boiler operation in Prussia is reported and illustrated by curves. The article shows that the number of explosions due to various causes is gradually decreasing and moreover, while, for example, the number of accidents due to careless attendance has increased during the last few years, the number of *explosions* due to this cause has decreased, which would indicate that boilers are being so built that they can withstand a certain amount of carelessness in handling without actually going to pieces.

A steamship is described having turbo-electric propulsion, the system at the steam end consisting of a Ljungström turbine, with a total ratio of transmission between turbine and propeller as 1:133.3.

In connection with the utilization of coke as fuel under boilers, the Belani grate is described, with its provision for igniting the coke before it reaches the traveling grate.

Of the papers presented before the American Institute of Mining Engineers are reported those on the manufacture and test of silica brick for the by-product coke oven, on mine pumping and a conveyor belt calculating chart.

From the Journal of the American Society of Naval Engineers are reported papers on the heat losses in steam engineering, methods of testing safety valves at the United States Naval Experiment Station and on land storage of bituminous coal. The latter paper is of particular interest as it raises grave doubts as to the effective ability of the United States Navy coal storage plants to safely store the amounts of coal for which they have been designed.

William Rodger, in a paper before the Canadian Railway Club, discusses the relative advantages of using hydraulic presses as compared with power presses for the manufacture of cartridges and shells.

Data on interesting tests of butterfly valves on locks in the Black Warrior region in Alabama, are abstracted from the Professional Memoirs of the Corps of Engineers, United States Army.

## FOREIGN REVIEW

**Internal-Combustion Engineering**

Diesel Engine Propelled Ship, *Pacific,* W. Kaemmerer.

Description of the Diesel engine propelled ship, *Pacific,* and its power plant.

The Burmeister & Wain Company, of Copenhagen, are the largest builders of Diesel engine ships. They now have under construction ten ships of 10,000 tons each, three of 9000 tons, six of 8000 tons, one of 7000 tons and three of 6500 tons.

The *Pacific* made its trial runs last December and was at once taken over by the owners, who proposed to use it for

the La Plate and Pacific Ocean business. It is 110 m. (360 ft.) long over all, 15.5 m. (50.8 ft.) beam, 7 m. (22.9 ft.) draught and has a capacity of 6500 tons. The engine room is very short and is located in the stern end of the ship. The ship has three decks and five loading hatches, each served by two electrically driven winches.

The power plant consists of two directly reversible 4-stroke cycle Diesel engines having each six cylinders, 540 mm. (21.2 in.) bore and 730 mm. (28.7 in.) stroke, delivering together 2000 i.h.p. Contrary to the practice of Diesel engine building in German shipyards, in this case the engines are enclosed and provided with lubrication under pressure. The arrangement, however, is such that the cylinders are left easily accessible. They are cast in blocks of three and although they are open on the bottom, the piston rods pass through stuffing boxes, the purpose of which is to prevent dirt from the cylinders falling into the lubricating oil. The pistons are comparatively short and are equipped with self-tightening rings. Each cylinder cover has built into it a fuel valve, suction, exhaust, starting and safety valves, the starting valve being water cooled. Each engine has six fuel pumps,—one for each cylinder,—all driven from a common shaft. The pumps take the fuel by suction from two tanks located in the engine room, containing enough fuel for a run of 24 hours. They are filled every twelve hours, which gives the oil a chance to deposit some of the impurities which it contains. The cross-heads of the engines have guides on one side and in all other respects are similar to those on steam engine driven ships.

In addition to the main engines, there are two auxiliary Diesel engines, likewise 4-stroke cycle, each driving a dynamo and compressor, and each delivering 200 i.h.p. at 225 r.p.m. For the usual requirements of the ship one engine is sufficient, the other serving merely as an auxiliary unit. Each compressor delivers air at from 20 to 25 atmospheres. This air is stored in two steel tanks, from which it is taken to start the engines. Each of the main engines has in addition a high pressure compressor which takes the air from the auxiliary compressor at 20 to 25 atmospheres and compresses it to 60 atmospheres. Each of the high pressure compressors is large enough to deliver the entire air blast for the two main engines. All the pumps (two centrifugal pumps for the cooling water, two centrifugal pumps for the oil under pressure, two charging pumps, and two pumps for drinking and service water) are driven separately by electric motors, the centrifugal pumps directly and the other pumps through gear transmissions.

When loading and unloading the ship, the compressors are uncoupled from the auxiliary Diesel engines which then serve to drive the dynamos exclusively. One dynamo is in most cases sufficient to deliver all the current required for the winches and the other auxiliary machinery and lighting purposes. When the winches are not at work and the operation of a large Diesel engine would be economical, the lighting current is supplied by a small 110-volt dynamo, driven by an ordinary 2-stroke cycle crude oil engine. This auxiliary dynamo also delivers current to drive a small high pressure air compressor furnishing compressed air for starting the auxiliary Diesel engines; this compressed air is stored in a separate tank which can be fully charged in two hours.

For heating purposes, there is installed in the rear end of the engine room a vertical boiler with oil firing. The total weight of the engine plant, with its entire equipment, auxiliary engines, pipes and repair parts, is 440 tons. The fuel which has to be carried for a return trip to South America is less than 700 tons, and therefore, as compared with the steamship, it can carry about 1000 tons more cargo. During test runs, the *Pacific*, with an output of 2032.5 i.h.p., has developed a speed of 11.41 knots. (*Das Motorschiff "Pacific," gebaut von Burmeister & Wain A.-G., Maschinen- und Schiffbau-Anstalt in Kopenhagen*, W. Kaemmerer, *Zeits. des Vereines deutscher Ingenieure*, vol. 59, no. 34, p. 677, August 21, 1915, 5 pp., 10 figs., *d.*)

## Oil and Suction Producer Gas Engines for Ship Propulsion

The article gives comparative data on the economy of operation of Diesel engines on one hand and producer gas engines on the other, as applied to ship propulsion.

The author believes that the producer gas engine cannot be dismissed as being uneconomical, even though it has not yet been brought up to its full perfection. He cites the following comparative data of operation of the two types of power plants (In the original article the figures are apparently misprinted and an attempt has been made in the abstract to give what would appear to be the correct figures. The doubtful figures of the original article are enclosed in straight brackets side by side with those which would seem to be the correct figures).

It is assumed that a marine Diesel engine consumes about 0.2 liter (0.21 qt.) of oil per h.p.-hr. Under these conditions, 100,000 h.p., at a price of 5 pfennigs per liter, will cost approximately 1000 marks (say $240). A suction gas engine of the same output, consuming 0.454 kg. (say 10 lb.) of anthracite per h.p.-hr. will burn, with anthracite at 24 marks per metric ton, approximately 1100 marks per 100,000 h.p.-hr. In order that such an engine should work as economically as a Diesel engine, the price of anthracite must go down to about 22 marks per ton. In this case, therefore, and in all others where Diesel engines are used having a fuel consumption as low as 0.2 liter per h.p.-hr., the suction engine is economically less efficient than the Diesel engine. If, however, the price of the Diesel engine oil goes up to say 6 pfennigs per liter, or 60 marks (say $14.85) per metric ton (2200 lb.) then the cost of fuel with the Diesel engine rises substantially to about 1250 marks per 100,000 h.p.-hr., while if the suction gas engine uses anthracite at 26 marks per ton, the cost of producing 100,000 h.p.-hr. goes up to only 1180 marks [1080 marks].

The above data just referred to can be considered as average prices for the two fuels and show a slight advantage in favor of the suction gas engines. It must, however, be borne in mind that the price both for oil and for anthracite is often higher. If now the suction engine be compared with a gasoline engine, the advantages in favor of the former will be still more pronounced. A gasoline engine consumes approximately 0.33 liter of fuel per h.p.-hr. and therefore 100,000 h.p.-hr. will cost about 2000 marks as compared with 1180 marks [1080 marks] for the suction gas engine of the same output.

The author states that the oil engine in its various forms is so well intrenched in its position that it is doubtful if in the near future the suction gas engine will find more favor in marine circles than it does to-day, but when this happens, the suction gas engine will be found fully efficient for marine propulsion (*Untersuchungen zwischen Schiffsöl-*

*und Sauggasmotoren, Polytechnische Rundschau,* supplement to *Elektrotechnische Rundschau,* vol. 32, no. 30/31, August 4, 1915, 2 pp., 3 figs., *ce*).

Maximum Contents of Hydrocarbons in Producer Gas, F. Hoffmann.

The author believes that in many cases the results of analysis of producer gas with respect to the contents of hydrocarbons are subject to doubt, and he thinks that it might be of interest to establish the limits within which the contents of hydrocarbons in producer gas can vary. With respect to producer gas made from bituminous coal, it can be established without particular difficulty.

It appears that this question has never yet been fully investigated. The author discusses first the generation of producer gas, and divides its constituents into the following four classes:

1. Steam.
2. Products of dry distillation, consisting mainly of tars, hydrocarbons and hydrogen, with a small addition of carbon monoxide and carbon dioxide.
3. Products of gasification, mainly carbon monoxide with carbon dioxide and hydrogen from steam supplied into the producer.
4. Nitrogen which comes mainly from the air supplied for the purposes of gasification and only to a very slight extent from nitrogen in the coal (under certain conditions, such as leaks in the piping, some air may be found in the producer gas, shown during the analysis by the presence of oxygen in amounts larger than traces).

A good basis for the determination of the highest contents of the products of distillation in bituminous coal gas producers is given by the data obtained in the manufacture of illuminating gas. It must, however, be remembered that computation based on average figures never strictly coincides with data actually obtained, especially as the conditions of dry distillation present in the manufacture of illuminating gas are not unessentially different from those in the manufacture of producer gas. With our present insufficient knowledge of the processes occurring in dry distillation of coal, we must be very careful how data of experience with pure dry distillation is transferred to dry distillation in the gas producer, particularly in view of the fact that the dry distillation in the producer occurs at a lower temperature (especially when much steam is added) than in illuminating gas retorts.

As a basis for calculation of the amounts of products of dry distillation, the author uses, chiefly, data of experiments obtained in the laboratory at Karlsruhe on test distillation of fifty of the most important kinds of German gas coals (published in *Journal für Gasbeleuchtung,* 1913-1914).

In analyzing the figures of the output, the contents in illuminating gas of nitrogen and various compounds of nitrogen and sulphur have been neglected in order to simplify the computations. This is permissible with respect to nitrogen because the nitrogen in the gas is due mainly to the unavoidable presence of air in the gasification chamber. On the other hand, K. Bunte has shown that of the nitrogen present in the coal, approximately 60 per cent passed into coke 20 per cent, as free gas, into the illuminating gas; 15 per cent into ammonia; 3 per cent into cyanogen and 2 per cent into tar, so that it may be assumed that when coal is gasified in a producer, practically 80 per cent of the nitrogen present in the coal will be found as gas in the producer gas. This is the figure which the author uses in his computation.

Table 1 gives the average output of gas of the most important German types of gas coals [referred to pure coal and the elementary composition of the gaseous products of dry distillation obtained from 100 kg. (220 lb.) of pure coal]. This table shows that the gases of distillation as obtained from 100 kg. of pure coal are essentially as follows:

9.346 kg. Carbon + 3.685 kg. Hydrogen + 3.423 kg. Oxygen.

The author then proceeds to discuss the output and composition of the tar formed in dry distillation and comes to the conclusion that if nitrogen and sulphur be neglected the following formula would hold good: in 100 kg. of tar there are 92.5 kg. Carbon + 4.4 kg. Hydrogen + 2.2 kg. Oxygen. (*Die Maximalgehalte des Generatorgases an Kohlenwasserstoffen,* Fritz Hoffmann, *Feuerungstechnik,* vol. 3, no. 22, p. 269, August 15, 1915, article not finished, and abstract will be continued in an early issue.)

TABLE 1A AVERAGE GAS OUTPUT FROM THE PRINCIPAL GERMAN GAS COALS (REFERRED TO PURE COAL)

| Average of Tests: | Total output of gas | $C_nH_m$ | $CH_4$ | $CO_2$ | CO | $H_2$ |
|---|---|---|---|---|---|---|
| | | (in cbm.: 1 cbm. = 35.314 cu. ft.) | | | | |
| 16 samples of Saar coal..... | 36.6 | 1.21 | 10.51 | 0.82 | 3.41 | 18.9 |
| 14 samples of Ruhr coal..... | 34 2 | 1.08 | 9 70 | 0.54 | 2.78 | 18.6 |
| 10 samples of upper Silesia coal..................... | 34.2 | 1.11 | 9 34 | 1.03 | 3.98 | 17.2 |
| 11 samples of other German coals..................... | 34.7 | 1.03 | 10 33 | 0.70 | 3.10 | 17.8 |
| Average of the above 50 samples..................... | 35.0 | 1.11 | 10.09 | 0.76 | 3.28 | 18.2 |

TABLE 1B COMPOSITION OF GASES OF DISTILLATION (FROM 100 KG., OR 220 LB. OF PURE COAL)

| | Absolute output of gas in cbm. | Relative weight of 1 cbm. in grams | | | Absolute weight of output of gas in grams | | |
|---|---|---|---|---|---|---|---|
| | | C | H | O | C | H | O |
| $C_nH_m$........ | 1.11 | 1610 | 210 | .. | 1787 | 231 | .. |
| $CH_4$ ........ | 10.09 | 535 | 180 | .. | 5398 | 1816 | .. |
| $CO_2$ ........ | 0.76 | 535 | .. | 1428 | 405 | .. | 1081 |
| CO ........ | 3.28 | 535 | .. | 714 | 1756 | .. | 2342 |
| H | 18.2 | .. | 90 | .. | .. | 1638 | .. |
| Total.... | 33.4 | | | .. | 9346 | 3685 | 3423 |

Gas Turbine, Alfred Walter.

Discussion of the question of the gas turbine.

The author believes that the entire problem is handled in a wrong manner and especially that insufficient attention is paid in the attempts to design a gas turbine to the designs of steam turbine engineering. He objects, for example, to the rather general assumption that in a gas turbine only an impulse wheel should be used and that the waste heat of the exhaust gases should be utilized in a regenerator.

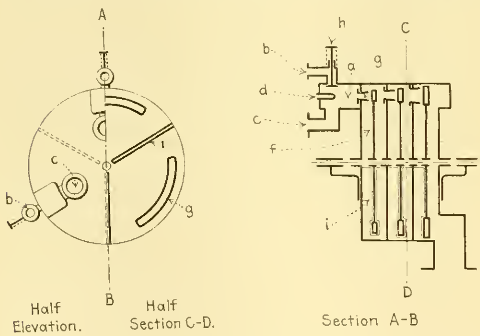
While he believes that in general the tendency in the development of the gas turbine is towards the ideal Carnot

cycle, he points out that the reciprocating steam engine as a periodical machine and the turbine as a continuously acting machine, go along entirely different roads toward the common goal,—the Carnot idea.

With particular reference to the gas turbine, the author believes that a great obstacle to its development lies in the assumption of the theoretical superiority of the explosion type of turbine over the constant pressure turbine. One cannot help objecting to placing a blade wheel in front of a periodical mechanism (explosion chamber with many valves), even though theory says that that is the right way to do. The author asks why one could not get some sort of an arrangement which would allow a continuous or at least a long period flow of gases of combustion to the turbine wheel. As regards the explosion turbine, he believes that there is a limit to its possible development. Its first successes were due to the fact that it represented the most primitive combination of an explosion motor and a turbine. Actually, however, in order to secure continuity of work, chamber on chamber have to be added with numberless valves and rods, and if so, what becomes of the simple gas turbine sought for?

The author attaches particular importance to a clear understanding of the following four points:

*a.* Since a pure continuous constant pressure process is practically impossible, processes should be selected which permit the greatest amount of continuity, such, as for example, the constant pressure process having long periods in which the period of combustion per chamber must be drawn out as long as possible with the temperatures obtaining under possible cooling.




Walter Gas Turbine Fig. 1

*b.* A powerful cooler should be installed both for the combustion chambers and the entire turbine, without, however, excessive consumption of fuel and loss of heat.

*c.* An attempt should be made to use a simple impulse wheel or normal turbine device (multiple wheel and drum, impulse and reaction), which afford the best results with respect to efficiencies, mechanical strength and wear.

*d.* The question should be considered as to how the exhaust heat may be utilized in other ways than by means of a regenerator.

In addition to the above, the author describes a novel process of his own, in which the usual constant pressure method is used, but the working cycle occurs, though intermittently, still at long periods. The air is admitted to the combustion chamber continuously under constant pressure and the air of combustion and the cooling air are admitted by the same pipe. The fact that the pressure in the combustion chamber is approximately constant makes it possible to use the normal type of turbine, in addition to which provision is made for a strong cooling of the entire turbine.

The large amount of air which has to be used in connection with this process appears to be a disadvantage at first, but the author claims to be able to show that this is what makes the process possible at efficiencies which are not excessively unfavorable. Fig. 1 shows the diagrammatic construction of the turbine. There are assumed to be three combustion chambers, *a*, of which two are working and one is in the state of being cooled. Through the pipe *b* the fuel is admitted into the combustion chamber and through pipe *c*, the air. In the combustion chamber is found further the ignition device *d* (hot bulb or electric). In all the three chambers the same pressure prevails. All the three chambers are freely connected with the turbine space *f*, by expansion nozzles *g*. Into the chamber which is being cooled at the time there flows from the compressor, air through pipe *cd;* this air takes up the residues of combustion and expands in the nozzle *g*, delivering some work to the turbine so that a certain part of the energy consumed by the compressor is again recovered in the turbine.

The expansion produces a powerful cooling of the air in addition to which the air constantly takes hot water from the walls of the turbine wheels, which constitutes a further addition to the work done by the air. In this light, the minus in heat loss of gases of combustion through cooling really appears as a plus. After the completion of the cooling period, the automatically operated fuel valve *h* opens and the fuel is blown into the combustion chamber through pipe *b*, mixes there with air and is ignited.

A proper shape of combustion chamber adapted to the kind of fuel used will produce either rapid or slow combustion. The mixture is expanded through the nozzle *g* and does its work in the turbine. Owing to the fact that in the chamber *a*, there prevails an approximately constant pressure, it is possible to build the turbine with more than one wheel and to obtain in this way conditions of work and efficiencies approximating those used in steam turbine construction. This has the further advantage that the cooling of the entire turbine is made possible, which depends on the conditions of flow in the turbine.

The author claims for this construction the advantage of having a small number of parts the motion of which has to be controlled, high thermodynamic and mechanical efficiency, low gas velocities and speeds and efficient utilization of the cooling air.

(*Gedanken und Anregungen zur Frage der Gasturbine*, Alfred Walter, *Zeits. für das gesamte Turbinenwesen*, vol. 12, no. 23, p. 265, August 20, 1915, article not finished, *td.*)

## Materials of Construction

### Properties of Metals at Higher Temperatures, P. Ludwik

The article is devoted to an investigation of the properties of metals at higher temperatures. The following metals have been investigated: aluminum, lead, cadmium, wrought iron, cast steel, copper, magnesium, brass, nickel, zinc and tin.

All the metals were taken in wire form, commercial brands

of the highest purity obtainable. The length of the test bars was approximately 60 cm. (23.6 in.). The bars were heated in an electric furnace, the temperature being measured by various thermo-elements. In all tensile tests, the following values were determined:

The original cross-section of bar $f_o = \frac{\pi d_o^2}{4}$

The test temperature

The highest load obtained $P$

The cross-section of bar $f$

The cross-section at the place of rupture $f_b$.

Then

$K_z = \frac{P}{f_o}$ is *tensile strength*

$\sigma = \frac{P}{f}$ is *tensile stress*

$100 \frac{f_o - f_b}{f_o}$ contraction, in per cent

$100 \frac{f_o - f}{f_o}$ uniform elongation, in per cent.

Contraction and corresponding elongation give at the same time the limiting values of elongation on rupture of pieces of various lengths.

As regards the various metals investigated, the following remarks are of interest:

*Aluminum.* With increasing temperature, the hardness and strength steadily decrease, while the ductility and malleability steadily increase. At 500 to 600 deg. cent., the latter was so great that aluminum, like lead, could be drawn to a fine point.

*Wrought Iron.* While the iron tested was not chemically pure, it was of very low carbon content (the chemical analysis indicated 0.06 per cent carbon, 0.47 manganese, 0.037 phosphorus and traces of silicon). The curves in Figs. 2A and B make clearly apparent the well-known fact that at the so-called blue heat (about 250 to 300 deg.) there is a higher strength with greater brittleness. At 600 deg. the ductility is at its maximum. Of interest also is the rise of tensile strength at about 800 deg.

*Cast Steel.* Virtually it was hard wrought iron close to the steel limit. As in the case of wrought iron, the maximum of strength and brittleness was reached at about 250 deg. At about 600 deg., likewise, the ductility is at its maximum.

*Copper.* A decrease of strength with increase of temperature is continuous down close to the melting point. The contraction of area materially decreases between 200 and 600 deg., increases at about 800 deg. and starts to decrease again above it.

*Brass.* Strength and ductility decrease as a rule with increase of temperature.

As regards the metals in general, the variation of strength with temperature falls into two main classes. The pure metals, with the exception of iron and nickel, show a fairly constant decrease of strength with temperature, while iron and nickel, as well as most of the alloys, show pronounced variations within certain characteristic regions of temperature which the author ascribes to allotropic transformations occurring at those temperatures.

The author discusses in considerable detail the question of variation of specific heat of metals with temperature and brings out data on the relation between the heats of melting and volume moduli. An interesting part of the article is that devoted to the consideration of the relation between the atomic volumes of metals on the one hand and their hardness and strength on the other. (*Festigkeitseigenschaften und Molekularhomologie der Metalle bei höheren Temperaturen*, P. Ludwik, *Zeit. des Vereines deutscher Ingenieure*, vol. 59, no. 33, p. 657, August 14, 1915, 8 pp., 9 figs., *etA.*)

### Brittleness of Wrought Iron as a Consequence of Heating Compressed Material, R. Baumann

The article is a communication from the Institution for Testing Materials of the Royal Technical High School at Stuttgart.

The tests carried out have been prompted by the observation that boiler plate, which has been deeply notched during the process of knocking off boiler scale, proved to be very brittle, which may have been due to the action of compression

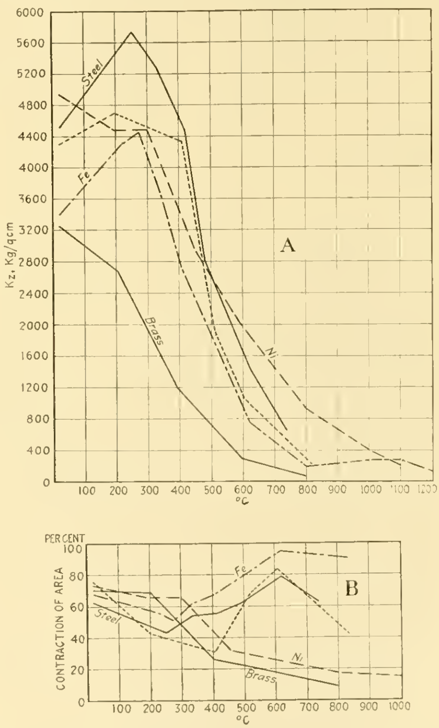



Fig. 2 A: $K_z$. "Tensile Strength" of Metals at Various Temperatures; B: Contraction of Area of Metals at Various Temperatures

together with subsequent heating to a sufficiently high temperature. Tests have also shown that other kinds of boiler material developed after cooling a considerable amount of brittleness if previously compressed and then heated to a yellow color. This may afford an explanation for many cases of rupture of boiler plates and the formation of cracks, as com-

pression and subsequent heating are phenomena of frequent occurrence.

As a rule the presence of deep notches or compression alone are not enough to produce material brittleness. To bring this about, it is necessary that a corresponding amount of heat be applied, and that, further, the constitution of the material be of a certain definite nature. Often test bars made from the same plate do not become brittle to the same extent. The old rule, that unnecessary notches should be avoided, etc., has not been discredited by the present tests.

The author describes a process which has been applied for testing boiler plate and established the inferior quality of some plates, which had passed the usual tests satisfactorily, but developed cracks in actual service. This test consists in pressing a cylinder of hardened steel 10 mm. (0.39 in.) in diameter against the face of the plate normally to the skin due to rolling and at an angle of 60 deg. to the axis of the bar; loading with a pressure of 2500 to 3000 kg. per cm. of length of bar subjected to pressure (13,750 to 16,500 lb. per in.), the thickness of the test bar being 15 mm., and then heating the bar to a yellow color and bending it after cooling in water.

The tests were carried out on plates 20 mm. thick (0.78 in.) having a tensile strength of 4100 kg/qcm. (say 58,000 lb. per sq. in.). The behavior of plates of greater thickness and higher tensile strength has not been established by the present tests.

The tests have clearly established the influence of direction of rolling, a fact which has to be taken into consideration in performing notch shock tests. (*Sprödigkeit von Flusseisen als eine Folge der Erwärmung gequetschten Materials*, Richard Baumann, *Zeits. des Vereines deutscher Ingenieure*, vol 59, no. 31, p. 628, July 31, 1915, 4 pp., 12 figs. *ed.*)

## Railway Engineering

Saving of Fuel on Locomotives by the Use of Feedwater Preheating, Strahl.

Careful consideration of data on the saving in coal and increase of output of locomotives by means of preheating the feed water (compare Table 2), indicates that the use of exhaust steam preheaters gave a saving of 13 to 19 per cent (in accordance with the type of construction and load on the boiler), as compared with similar locomotives without preheaters. But when a waste gas preheater was installed in addition to an exhaust steam preheater, the saving rose to 19 to 27 per cent, or from 6 to 8 per cent more, which is quite a material increase in economy. Actually during test runs on the Prussian State railways, of wet steam and superheated steam locomotives on which exhaust steam superheaters were subsequently installed, the saving of coal within the above limits was established beyond dispute; often it rose to over 20 per cent.

TABLE 2 DATA OF TESTS ON THE EFFECTIVENESS OF PREHEATING ON LOCOMOTIVES AS A MEANS OF SAVING FUEL

| Specific Load on Grate of Locomotive $\left(\frac{Bh}{10^6}\right)$ without Preheater | | Locomotives with | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Exhaust Steam Preheating | | | | Exhaust Steam and Waste Gas Preheating | | | |
| | | Wet Steam | | Superheated Steam | | Wet Steam | | Superheated Steam | |
| | | $t'_r = 360°$ | $t'_r = 320°$ | $t'_r = 360°$ | $t'_r = 320°$ | $t'_r = 360°$ | $t'_r = 320°$ | $t'_r = 360°$ | $t'_r = 320°$ |
| 2 | Temperature of preheated feed-water, deg. cent. | 90 | 90 | 90 | 90 | 130 | 122 | 134 | 126 |
| 4 | | 100 | 100 | 100 | 100 | 144 | 136 | 150 | 141 |
| 2 | Heat required for the production of 1 kg. of steam, in calories | 570 | 570 | 634 | 634 | 530 | 538 | 590 | 598 |
| 4 | | 550 | 550 | 635 | 635 | 506 | 514 | 585 | 595 |
| 2 | Heat required for the production of 1 kg. of steam from feed water at 10 deg. cent. | 650 | 650 | 714 | 714 | 650 | 650 | 714 | 714 |
| 4 | | 640 | 640 | 725 | 725 | 640 | 640 | 725 | 725 |
| 2 | Efficiency of boiler without preheater | 0.698 | 0.718 | 0.698 | 0.718 | 0.698 | 0.718 | 0.698 | 0.718 |
| 4 | | 0.576 | 0.596 | 0.576 | 0.596 | 0.576 | 0.596 | 0.576 | 0.596 |
| 2 | Efficiency of boiler with preheater *at the same* output | 0.713 | 0.733 | 0.711 | 0.732 | 0.721 | 0.739 | 0.719 | 0.738 |
| 4 | | 0.610 | 0.630 | 0.607 | 0.627 | 0.627 | 0.644 | 0.623 | 0.640 |
| 2 | Saving in coal *at the same* output due to preheater | 14 | 14 | 13 | 13 | 21 | 20 | 20 | 19 |
| 4 | | 19 | 19 | 17 | 17 | 27 | 26 | 25 | 24 |
| 2 | Temperature of waste gases, in deg. cent. | 322 | 284 | 322 | 284 | 230 | 209 | 230 | 209 |
| 4 | | 392 | 348 | 392 | 348 | 292 | 266 | 293 | 267 |

$t'_r$ = temperature in the smoke-box.

While the saving in coal on locomotives with exhaust steam preheaters in average operations was actually found to be considerably below these figures, hardly exceeding 10 to 11 per cent, this was due to the fact that either the increased capacity of the locomotive could not be utilized beyond a certain limit, or during runs with closed throttle or during periods of standing at stations, the preheating was not available, which affected the results even though feeding the boiler during such periods was avoided as carefully as possible. In this respect, the situation with the waste gas preheater is much more favorable, since the waste gases may be used for preheating the feed water even when the throttle is closed.

The average saving of fuel through preheating by exhaust

steam is the greater the less frequently the throttle has to be closed during the operation of the locomotive. Hence, the economical advantages of feed water preheating on locomotives operating express trains and fast freight trains which make long runs without stopping, is of greater importance than in local passenger trains and ordinary freight train service, and is greater in regular service than on switching locomotives. It is quite possible, and sometimes happens, that the economical advantages of exhaust steam preheating may become entirely insignificant, especially on locomotives which even without preheaters have a sufficient output and the ratios of dimensions are the same as on the superheated steam locomotives of the Prussian State Railways, or 20 to 25 per cent with a smaller ratio of heating surface to grate surface. In good accord with this is the information given by Trevithick, managing director of the Egyptian State Railroads, concerning runs of their superheated steam locomotive, No. 712. The feed water was preheated by an exhaust steam and a waste gas preheater connected in series, to a temperature of 145 deg. cent. With this locomotive a saving of 20 per cent, as compared with two superheated steam locomotives without preheaters, was secured, and with another

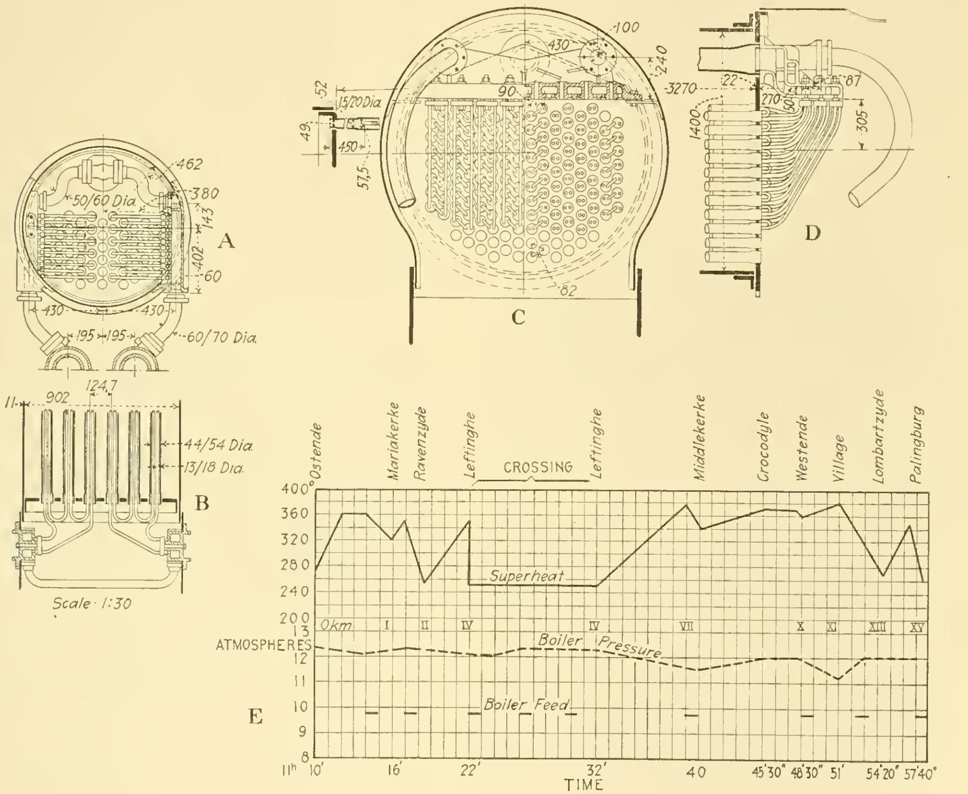



Fig. 3 Locomotive Superheaters with Tubes of Small Diameter

leave but little to be desired with respect to steam generation. It is advisable to install preheaters on locomotives which need them; e.g., when the boilers are already overloaded.

In order to best utilize the increased output of the boiler, it is advisable on new locomotives on which the feed water preheater is installed, to increase the size of the steam cylinders, since otherwise increases of load are possible only to a limited extent. If, however, the size of the cylinders is adapted to the increased output of the boilers, excellent results can be obtained.

The saving of coal by feed water preheating on superheated steam locomotives with exhaust steam and waste gas preheating, amounts to approximately 19 to 24 per cent if similar locomotive, No. 711, a saving of even 27 per cent was obtained, as compared with 29 other locomotives. The latter saving is considered by Trevithick to be too high, because Locomotive No. 711 was placed on test runs when new and was therefore in first-class condition. (*Die Kohlenersparniss oder grössere Leistungsfähigkeit der Lokomotiven durch Vorwärmung des Speisewassers*, Strahl, *Annalen für Gewerbe und Bauwesen*, vol. 77, no. 2/914 and 3/915, July 15 and August 1, 1915, *pe.*)

Small-Smoke-Tube Superheaters for Locomotives, Metzeltin.

Description of recent developments in the design of Schmidt superheaters, in particular for locomotives.

The modern type differs from the older type in that the large smoke tubes have been eliminated and the entire boiler filled with tubes of diameter only slightly larger than that of fire tubes hitherto used. The space saved in this manner has been largely, if not exclusively, occupied by superheater elements. This type of superheater construction has several advantages which have been established in practice, as follows:

They give a more rapid and higher superheating than the old smoke tube superheater, and therefore are particularly convenient for street railway service and local lines where many stops have to be made. With the same boiler diameter, the new type of superheater, which is called the "small-smoke-tube" superheater, can utilize about 30 per cent more heating space than the old superheater with large fire tubes could do.

The use of smoke tubes of moderate diameter has above all the great advantages that the walls of the tubes are not exposed to the high stresses which may occur with large smoke tubes. Smooth tubes, 50 to 70 mm. (1.96 to 2.75 in.) in diameter in long boilers, are apt to sag somewhat during the runs of the locomotive, due to their own weight and vibration, so that they cannot offer any great resistance to increase of length on account of the heating. On the other hand, larger tubes of 125 to 133 mm. (4.9 to 5.2 in.) in diameter, often with lengths of 5 to 6 m. (16.4 to 19.69 ft.), do not bend at all and therefore do not yield in any way with rises of temperature. The manipulation of the small-smoke-tubes is no more difficult in locomotive shops than that of larger tubes. The Netherland Tramway Company, in Herenveen, have had 30 tender locomotives with fire tubes 50 mm. (1.9 in.) and superheater tubes 11 mm. (0.42 in.) in diameter, in use for three years without experiencing any serious trouble.

The superheater elements of the small tube superheaters consist usually of 4 or 6 tube bunches, which in their turn consist of two or three tubes. The first arrangement of the steam collector chamber used was such that the chamber was located vertically, parallel to the exhaust blast tube in such a manner that the superheated steam space was in front and the wet steam space behind. This arrangement has the advantage as it is very simple. An arrangement which is considered to be very good is shown in Figs. 3A and B, representing the superheater for a street railway locomotive of the Mass-Buurt railway in Holland. There, each of the steam collector chambers, located to the right and to the left, is divided in two parts for the superheated steam and wet steam. This arrangement permits a very good design of the superheater elements, the two superheated steam collectors being inter-connected by a pipe 40 to 50 mm. (1.5 to 1.9 in.) in diameter. The arrangement shown in Figs. C and D is widely used on the Belgian, Hungarian and Italian railways.

As to the results gained with small-smoke-tube superheaters, an idea may be obtained from the chart in Fig. E, representing curves established by a test of a C-type street railway locomotive on the Belgian local railways. Special attention is called here to the fact that temperatures of 340 to 380 deg. could have been maintained for a comparatively long time. (*Kleinrauchröhren-Ueberhitzer für Lokomotiven,* Metzeltin, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, no. 32, p. 645, August 7, 1915, 6 pp., 21 figs. *d.*)

**Steam Engineering**

Concerning the Increase in Safety of Boiler Operation in Prussia, B. Hilliger.

The author attempts to prove that the number of boiler accidents in Prussia has decreased during the last few years. He divides all accidents into three groups,—explosions,

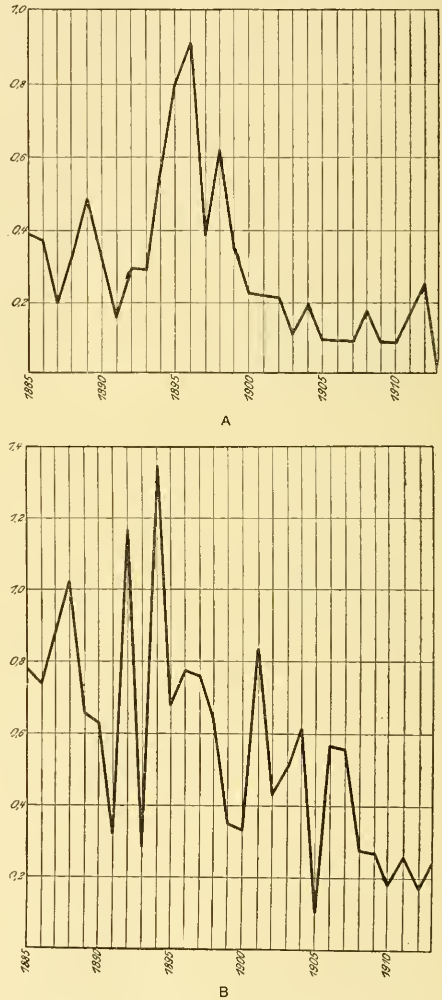



Fig. 4 Explosions (per Unit of 10,000 Boilers) Caused by (A) Defects in Material and Workmanship, and (B) Defective Attendance

accidents which lead to the boiler being put out of operation and various defects producing accidents. In the main, disturbances in operation are produced by one of the following four causes: *first,* defects in material and workmanship; *second,* piping, connections and auxiliary apparatus; *third,* attendance, and *fourth,* operating conditions. He reports his data in the form of tables and curves, some of which are here reproduced. Fig. 4A shows the number of boiler ex-

plosions caused by imperfections in material and workmanship, referred, for purposes of comparison in various years, to a unit of 10,000 boilers. The great jump in the number of boiler explosions between 1894 and 1897 is due to the fact that during that time a different definition of boiler explosion was used by the statistical office.

Under the class of explosions due to boiler piping, connections and auxiliary apparatus, are handled all accidents due to jammed or overloaded safety valves, clogged or incorrect manometers or finally, defective feed water apparatus; also accidents due to the clogging of passages leading to the water gages and incorrect indication of water level by the gages. The curve shown indicates that the number of accidents reported as due to this cause is comparatively small and varies widely in different years, which, under these conditions, may be due to accidental causes.

The number of accidents due to lack of proper attendance appears to be comparatively large. Explosions in these cases are very often due to lack of water in the boiler, which can be traced to the carelessness of the fireman. Fig. B indicates the gradual falling off in the number of explosions. (The reasons for an unusual increase of explosions as shown by the curve for the periods 1894 to 1897 has been explained above.) In this connection, the author points out a curious phenomenon,—namely, that statistics indicate that the number of accidents due to careless attendance on boilers has increased in the last few years, while the number of *explosions* due to this cause, has decreased. Since the majority of accidents due to this cause are produced by low water level, it would appear that the boilers are being so built that they can better withstand trouble of this nature. Table 7 offers an opportunity of judging the tendencies in explosions and accidents in boiler plants by giving a comparison between what took place from 1885 and 1889 on one hand, and from 1909 to 1913 on the other. The same data are represented by curves in the original article. (*Untersuchungen über die Zunahme der Sicherheit der Dampfkesselbetriebe in Preussen*, B. Hilliger, *Zeits. des Vereines deutscher Ingenieure*, vol. 59, no. 34, p. 681, August 21, 1915, 7 pp., 10 figs., *s.*)

TABLE 3. COMPARATIVE DATA SHOWING THE VARIATION IN THE NUMBER OF BOILER ACCIDENTS IN THE LAST 18 YEARS

| Causes | Explosions to each 10,000 boilers in the period: | | Accidents to each 10,000 boilers in the period: | |
|---|---|---|---|---|
| | 1885–9 | 1909–13 | 1885–9 | 1909–13 |
| Defects in material and workmanship | 0.352 | 0.120 | 4.48 | 1.78 |
| Defects in piping connections and auxiliary apparatus | 0.246 | 0.069 | 2.04 | 1.84 |
| Defective attendance | 0.815 | 0.225 | 5.83 | 6.82 |
| Defective operation | 0.351 | 0.135 | 5.26 | 3.90 |

## Swedish Ship with Turbo-Electric Propulsion

The Swedish coaster, Mjölnir, was built by the Lindholmens Verksted, in Gotenburg, and has a displacement of 2250 tons, a speed of 11 knots, is 68.6 m (225 ft.) long, with 10.97 m (36 ft.) beam and 4.5 m (14.7 ft.) draught. The propeller shaft, which carries a single screw, is driven by two synchronous motors, arranged to transmit their power through a gear transmission with two pinions, each motor operating on one pinion. This transmission reduces the speed from 900 r.p.m. on the motor shaft to 90 r.p.m. on the propeller shaft, the total power delivered to the propeller shaft at 90 r.p.m. being about 900 h.p. The current is generated by two 500 volt, 100 cycle alternating current dynamos, having an output of about 400 kw. each, at 6000 r.p.m. These data indicate that the ratio of transmission between turbine and propeller is extremely high; in fact it is 1:133.3, and this permits the obtaining of a comparatively low steam consumption, notwithstanding the moderate size of the power unit. Although no complete data of any test of the engine have been published, it is expected that the steam consumption will be about 4.5 kg. (9.9 lb.) per shaft h.p.-hr. In runs made previous to delivery simultaneously with the sister ship, Meiner, driven by triple expansion steam engines, it was found that the new ship had a coal consumption 35 per cent

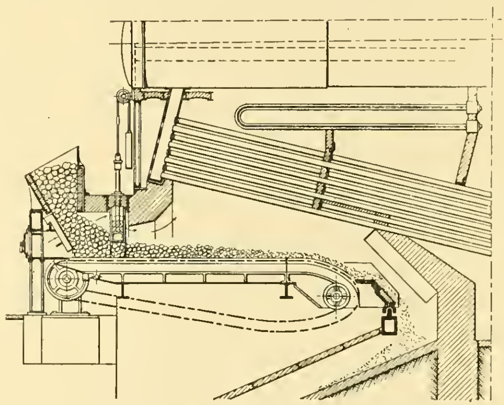


Fig. 5 Belani Grate for Burning Coke under Boilers

less than the other steamer. (*Ein neuer turbo-elektrischer Schiffsantrieb*, F., *Zeits. für das gesamte Turbinenwesen*, vol. 12, no. 23, p. 274, August 20, 1915, 1 p. *d.*)

## Coke as Fuel Under Boilers, H. Markgraf

In a previous issue of *The Journal* (September, 1915, p. 558) reference has been made to efforts in Germany to supplement the lack of the usual coal fuel by the utilization of coke, and to various experiences in this connection. The present article covers approximately the same ground in a more detailed way, and brings up some comparatively new data.

First, the author points out that, contrary to the prevailing impression, the temperature of combustion coke is lower rather than higher than that of coal. He shows that in order to attain the same temperature in the furnace, the combustion of coke must be much more complete than that of coal. Judging temperature by the color of the flame with the naked eye is apt to lead to errors. Coke flame is brighter than coal flame but that does not prove that its temperature is higher, because the coal flame is rendered somewhat darker by the presence of decomposing hydrocarbons and carbon particles resulting from this decomposition.

The greatest trouble was experienced in attempts to burn coke on traveling grates which had been designed mainly to

take care of fuels rich in gas, but not those containing little or practically no gas, such as coke. There must be found therefore some other way of igniting the fuel coming into the furnace than by the use of a zone of incandescence produced by a glowing arch. This seems to have been accomplished by engineer Belani, of Essen, Germany. In his arrangement shown in Fig. 5, there is provided a sort of preignition where the coke is ignited before it reaches the traveling grate, which makes the action of the arch entirely superfluous. The pre-igniting device which supersedes the usual fuel supply hopper and has about the same dimensions as the latter, consists of a funnel shaped shaft, lined with fire bricks, equipped at the front with an inclined grate and connected on the other side by a passage with the fire chamber of the boiler. Under this connecting passage there is provided a slide valve regulating the height of fall of the fuel. The device is operated as follows:

First, the furnace is filled as far as the grate bars with coke which has been previously brought up to a state of incandesence. Then the entire hopper shaft is filled with fresh coke. As a result of the chimney draft, air is drawn in between the grate bars and through the glowing layer of coke, while the gases of combustion generated there go through the passage above referred to, directly into the boiler furnace. As the parts of coke lying on the traveling grate in a state of incandescence are drawn away, fresh coke is supplied from the hoppers.

Tests of this apparatus are said to have given satisfactory results. (*Die Verwendung von Koks zur Dampferzeugung*, Dr.-Ing. H. Markgraf, *Stahl und Eisen*, vol. 35, no. 33, p. 847, August 19, 1915, 6 pp., 2 figs. *o.*)

## ENGINEERING SOCIETIES

### AMERICAN INSTITUTE OF MINING ENGINEERS

*Bulletin, no. 105, September 1915, New York City.*

Manufacture and Tests of Silica Brick for the By-product Coke Oven, Kenneth Seaver (abstracted)
Mine Pumping, Charles Legrand (abstracted)
Conveyor Belt Calculating Chart, J. D. Mooney and D. L. Darnell (abstracted)
Ventilation of the Copper Queen Mines, Charles A. Mitke
The Stresses in the Mine Roof, R. Dawson Hall
Standardizing Rock Crushing Tests, Myron K. Rodgers

#### Manufacture and Tests of Silica Brick for the By-product Coke Oven, Kenneth Seaver

The paper describes methods of manufacture and testing for the determination of effects of burning of silica brick.

American practice in the manufacture of silica brick is far above that of any other country. As the author states, in some instances, European manufacturers have refused to credit the possibility of making to such specifications as are common in this country until the actual completed shapes were shipped for inspection.

By silica brick, the author understands only a brick having a silica content of 94 per cent or more and made usually from quartzite with a small percentage of lime as a binder. He discusses in detail the materials used, such as Pennsylvania, Wisconsin and Alabama quartzite, and its various stages of manufacture, such as quarrying, grinding, molding and burning, and, in the latter connection, gives data concerning the effect of burning on composition, expansion and physical strength of the brick. He comes to the conclusion that while by quick burning, brick may be easily expanded to double or treble the normal amount, this is not conducive to the production of sound brick. In general, he believes that the present good commercial practice carries the results of the quartz-cristobalite inversion to the greatest degree economically possible. He reports also a series of tests having for their primary object the determination in how far the inversion from quartz to cristobalite has progressed under various conditions. (14 pp., 3 figs. *ep.*)

#### Mine Pumping, Charles Legrand

This paper is a discussion of the questions of mine pumping, such as the selection of proper pumps under various conditions, the design of the pump, especially its piston and packing, and the selection of the driving plant and transmission. A number of tests are reported in tabular form on several sizes of steam and electric pumps, as well as on air lifts. With the latter, in the best test for 200 ft., 1680 gal. per min. of water were delivered. (6 pp. *e.*)

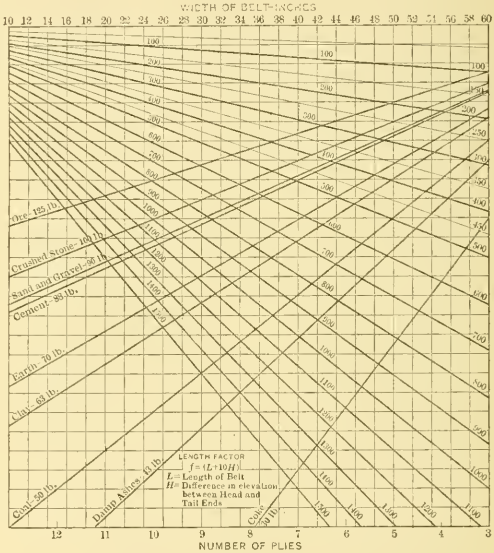



Fig. 6 Conveyor Belt Calculating Chart

#### Conveyor-Belt Calculating Chart, J. D. Mooney and D. L. Darnell

The chart shown in Fig. 6 has been drawn as a means to determine quickly the correct number of plies of conveyor belts operating under specific conditions. The calculations are based on the average safe strength (factor of safety of 15) of the various standard rubber conveyor belts. The calculations assume a maximum load condition, i.e., the belt is considered as carrying the greatest load that it will handle without spillage at ordinary belt speeds, which produces the most economical operating conditions and maximum tension in the belt. The chart represents graphically the formula

$$p = kgW(L + 10H)$$

where $p$ = the correct number of piles; $k$ = constant de-

pending on the type of drive; $g$ = the weight in pounds per cu. ft. of material handled; $W$ = width of the belt in inches; $L$ = length of the belt in feet, approximately twice the center distance; $H$ = the difference in elevation between the head and tail pulleys in feet.

For a simple drive, with a bare pulley, $k = 1/250000$; for a simple drive with a rubber-lagged pulley, $k = 1/300000$; for a tandem drive with bare pulleys, $k = 1/375000$ and for a tandem drive with rubber-lagged pulleys, $k = 1/455000$.

The chart is drawn for a simple drive with a bare pulley and therefore the number of plies obtained from the chart should be multiplied by the factor 0.83 or 5/6 for simple lagged drive; a factor of 0.67 or 2/3 for tandem bare and a factor of 0.55 or 11/20 for tandem lagged drive.

The length factor $f = L + 10\ H$, represented on the chart by the lines 500, 600, etc. is a developed factor equal to the sum of the length of the belt and 10 times the difference in elevation between the head and tail pulleys.

To find the correct number of plies for a conveyor belt, knowing the width, length, difference in elevation between the head and tail ends and the kind of material to be handled, start from the width given at the top of the chart and move downward until this line intersects the line corresponding to the proper length factor; then move either right or left until the line corresponding to the given material is met; then move down again to the scale of plies where the next largest figure will give the desired correct number.

For example, to find the correct number of plies for a conveyor belt 36 in. wide and 300 ft. long, with 20 ft. difference in elevation, handling sand and gravel, follow the 500 length line; then follow to the right until the "sand and gravel line" is intersected; then down to the ply scale where the ply will be found to be 7. (3 pp., 1 fig. *p.*)

### AMERICAN SOCIETY OF NAVAL ENGINEERS

*Journal, vol. 27, no. 3, August 1915, Washington, D. C.*

Heat Losses in Steam Transmission, W. L. Cathcart (abstracted)
Manganese-Bronze, Lieut. J. B. Rhodes, U. S. N.
Method of Testing Safety Valves at the U. S. Naval Experiment Station, Ensign L. R. Ford, U. S. N. (abstracted)
Land Storage of Bituminous Coal, Geo. R. Crapo, Paymaster, U. S. N. (abstracted)

Heat Losses In Steam Transmission, W. L. Cathcart.

General discussion of heat losses in steam transmission, both for superheated and saturated steam.

The question of radiation and conduction is discussed from the point of view of the Stefan-Boltzmann law of radiation (in which the radiation of a black body is proportional to the fourth power of its absolute temperature).

For the external conduction, the author establishes formulae based on the general method of Mollier, the transfer of heat from one fluid to another, through an intervening solid, being divided into three stages: External conduction from the first fluid (steam) to the solid (pipe metal); internal conduction through the latter; and external conduction from the pipe to the second fluid (air). From the data obtained in Eberle's tests, the author calls attention to the fact that there is a marked difference between the values of $k_1$ (coefficient of external conductivity of steam to plate) for superheated and saturated steams. Saturated steam cannot lose heat without partial condensation and hence there is not only a film of condensate adhering to the interior surface of the pipe, but probably the column of moving steam has also a thin casing of condensate. The usual formulae do not consider these insulating films, since the heat transfer through them is too complex a process. With highly superheated steam, these conditions do not prevail, since the pipe, if properly protected, is hotter than the corresponding temperature of saturated steam.

The author reports fully the Péclet formulae for heat losses, both by radiation and by conduction. The heat losses of saturated steam in uncovered pipes are discussed in detail and a table is given where there are assembled data of 19 of the principal tests of uncovered pipes containing saturated steam. In this table are given the total losses as computed by Péclet's formula, and it is shown that the average correction to be applied to the latter is 0.3. The necessity for the correction is explained by the fact that the Péclet results were derived from laboratory experiments on apparatus of limited size, while under practical conditions, the condensate method involves possible errors.

The heat losses of covered pipes are likewise discussed. The article is of interest as giving a very clear presentation of a very important subject, combining data from the best sources (26 pp., *gt*).

Method of Testing Safety Valves at the U. S. Naval Experiment Station, L. R. Ford.

The article describes the method of testing safety valves at the United States Naval Experiment Station and in particular, the testing of the safety valves on the U. S. S. Nevada.

The requirements for safety valves are briefly reported and the experimental arrangement described in detail. The tests of springs are described in particular. The maximum fibre stress in the spring occurs at the middle of the inside edge of section of the spring coil and is made up of the four component stresses due to torsion, direct shear, bending and direct compression. The effect of the last two is sufficiently slight to be neglected. The first two produce a maximum shearing fibre stress, which is calculated for a valve lift of 0.100 in. by the following formula:

$$S = \frac{9Q \cos \theta R}{2\,bh^2} + \frac{Q \cos \theta}{A}$$

where $Q$ = load on spring in pounds; $R$ = the mean radius of the coil measured from the axis of the spring to the center of gravity of sections in inches; $\theta$ = the angle of inclination of coil to a plane perpendicular to the axis of the coil. The shearing modulus of the spring material is calculated for a valve lift of 0.100 in. by the following formula

$$d = \frac{Q \cos^2 \theta R^2 L}{CJG} + \frac{Q \cos^2 \theta L}{AG}$$

in which $d$ = axial deflection per coil in inches
$Q$ = load on spring in pounds
$R$ = mean radius of coil in inches by measurement
$p$ = pitch of coils in inches
$L = (p - d)^2 + (2\pi R)^2$ = length of one free coil in inches actively opposing the compression of the spring

$$\cos \theta = \frac{2\pi R}{L}$$

$C$ = St. Venants constant for the resistance to torsion of bars of nearly square section

$A = h \times \frac{B+b}{2}$ = area of section in square inches

$h$ = altitude of trapezoidal section in inches

$B$ = larger base in inches

$b$ = smaller base in inches

$$J = \frac{h}{48}(B^3 + B^2b + Bb^2 + b^3) + \frac{h^3}{36}\left(\frac{B^2 + 4Bb + b^2}{B + b}\right)$$

= polar moment of inertia of trapezoidal section in inches

$G$ = shearing modulus of elasticity in pounds per square inch (12 pp., 4 fig., *ed*).

Land Storage of Bituminous Coal; the Ever Present Factor of Spontaneous Combustion; and a Few Facts and Suggestions in Connection with Same, Geo. R. Crapo.

The writing of this article was prompted by the fact that from November 15, 1914, to February 20, 1915, a series of fires of a spontaneous nature, sixteen in all, took place in the coaling plant under the charge of the writer, at the Naval Station, Key West, Fla. From what appears in this connection, it seems that this matter of spontaneous ignition of coal is of far greater importance than is generally realized.

The plant at the Naval Station, Key West, Fla., consists of two steel sheds, one 150 x 100 x 20 ft. at the eaves, and the other 250 x 75 x 20 ft. at the eaves. From the above dimensions, using 42.5 as the average density of coal, it is seen that the plant was built for the purpose of storing 15,883 tons of coal within ready reach of the conveyors for rapidity of handling.

The best authorities contend, however, that coal cannot be safely stored at a depth of over 14 ft. and even at that depth, a careful watch must be kept constantly on it. This means that the plant, designed to store nearly 16,000 tons of coal in such manner that rapid discharging and loading of vessels can be effected, can be used only for the storage of 11,000 tons; it again means that if in case of war, the plant is called upon to work to full capacity and the coal is urgently needed, it would either be too hot to place safely in the vessel's bunkers, or the prolonged and continual heating would have so exhausted its calorific qualities as to render it poor steaming coal. It appears, therefore, that something is radically wrong; either the adopted system of storage or our lack of information on a subject of this importance.

The author discusses the conditions contributing to the ignition of coal. He calls attention to two very simple tests, showing in advance whether or not the coal in question can be safely stored. One of these tests is given by Professor Fisher, of Göttingen, as follows:

> Coals which absorb bromine rapidly are most liable to spontaneous ignition. Shake one grain of finely ground coal with 20 cc. of a half normal solution of bromine for a period of five minutes. If the smell of the bromine has then disappeared, the coal is likely to oxidize rapidly and is not a safe one to store.

Professor Lewes gives the following test:

> Coal that gains more than 2 per cent in weight when heated to 250 deg. fahr. for three hours, is a very dangerous coal to store.

The author discusses in detail the supposed causes of ignition. He comes to the conclusion that an open shed with just enough superstructure to support the overhead mechanical devices for use in the handling of the coal, is far superior and safer than the closed type. He does not believe that coal exposed in open air for, say one year, will lose all of its calorific properties. The Florida East Coast Railway and several shipping and commercial concerns keep varying quantities of coal at Key West in the open, often for considerably over one year, and the coal gives good average results for steaming purposes.

The overhead conveyor system, with the apron perhaps from 45 to 60 ft. above the floor of the shed, is very bad practice, *first*, because coal in its fall generates additional heat and before this heat can escape, another bucketful is dropped upon the first, and *second*, the coal falling from this height, breaks a large percentage of the lumps and creates more fine coal dust, which, in itself, is a dangerous element.

Too great dependence should not be placed on the temperature readings (which the author, however, strongly recommends to be made), as it very frequently happens that that portion of coal which fires first is not the portion which indicates the highest thermometer reading; often the portion first heated may get a draft of air in consequence of the heating and the heat then move and deposit elsewhere.

A promiscuous use of water in extinguishing fires in a coal pile is of practically no value. A coal pile will often heat almost to the point of coking and then subside, but if water is used at that stage, the coking will take place at once and coal will be lost which otherwise might be saved (12 pp., 1 fig., *gp*).

## CANADIAN RAILWAY CLUB

*Advance publication of paper read on September 14, 1915.*

Hydraulic Presses versus Power Presses for the Manufacture of Cartridges and Shells, Wm. Rodger.

The author discusses the question whether hydraulic or power presses are the more economical and efficient for the manufacture of cartridges and shells. He considers four types of presses: Steam Pump Presses, Hydraulic Presses, Motor Driven Power Presses and Direct Steam Presses.

*Steam Pump Presses.* Boilers are required to generate steam for the pumps and the pumps must be large enough to supply the water at the pressure and velocity to keep the accumulator up when the presses are in operation. A receiving tank, having direct connection with the water main, is also absolutely essential. With this type of press economy in steam power can be obtained by the use of a trip valve, operated automatically, which cuts off the steam when the press is not in operation. It is good policy to make the pumps 25 per cent larger than is actually required, as at times the pump is liable to give out with overload on the press.

*Hydraulic Presses.* In the case of a hydraulic press, the position of the presses should be determined relative to the pump and to the accumulator in order that the pipes may be arranged to eliminate right-angle bends, for the purpose of preventing sudden shocks and bursting of pipes, which would materially retard the output. In the manufacture of cartridges and shells, the writer is convinced that the use of an accumulator is indispensable; for example, should a triplex

pump, which gives a more even flow of water pressure, be used, a certain loss of energy would manifest itself; consequently, the pressure at the press would be oscillating in character, but this would be obviated by the use of an accumulator. It is often advisable to operate a press or other hydraulic tool direct from a pump without the use of any interposed accumulator, but for this special work it is essential that the accumulator be employed to give the desired results, as without its use any pressure from 1500 lb. per sq. in. upwards could be obtained without any means of regulation of the pressure.

A motor driven pump consists of a hydraulic plant operated by steam supplied to an electrical generating set, which in its turn supplies current to the motor driving the power pump; the electrical generating outfit being a high speed engine and having a short cut-off, it will use less steam and consume less fuel.

*Motor Driven Power Presses.* In the opinion of the writer the best method of placing the motor is to drive onto a countershaft, which, although it necessitates a special self-starting rheostat, permits the press to be driven by a smaller motor as the load or torque of the motor is overcome by the countershaft.

*Direct Steam Presses.* The direct steam press is not suitable for shell and cartridge making, as it is not possible to attain the required pressure per square inch at the back of the piston (11 pp., *p*).

## CORPS OF ENGINEERS, UNITED STATES ARMY

*Professional Memoirs, vol. 7, no. 35, September-October 1915, Washington Barracks, D. C.*

The Diesel Engine, Capt. John M. Wright

Butterfly Valve Experiments, Lieut. Col. Charles Keller (abstracted)

The Use of Outlets for Reducing Flood Heights, J. A. Ockerson

A Season with the Cement Gun, Major W. G. Caples

### Description of Tests of Butterfly Valves on Locks in the Black Warrior Region, in Alabama.

On the system of locks on the Warrior and Tombigbee Rivers, all the culverts except two are controlled by butterfly valves, either in pairs or in sets of three. These valves are set with their axes vertical, and are operated by hand through a simple worm and sector. On the whole, they have given satisfaction, but certain difficulties in their operation have led to the tests described in the article, and proper changes followed as a result.

The first eight locks built on the Warrior and Tombigbee Rivers were equipped with pairs of butterfly valves, 6 ft. 0 in. high, 2 ft. $10\frac{1}{2}$ in. wide, operated from the tops of the walls. At three of these locks, each valve was set in an independent frame and operated as a single unit by a simple lever keyed to the top of the shaft. At the other five locks, the valves were operated in pairs by a worm and quadrant gear. With three valves thus connected to a worm and gear device, it was found that the total moment which one man could exert was 58,020 in.-lb., or 19,340 in.-lb. to each vertical shaft, which was not enough with heads of over 10 ft. to permit a single operator to open a set of three valves to normal position.

The difficulty of operating three valves keyed to a single hand wheel was attributed to two causes: *First,* when two or more valves are operated simultaneously, the water deflected from the first or upstream valve, when partly open, comes in contact with and tends to close the second valve; the stream deflected from the latter offers a similar resistance

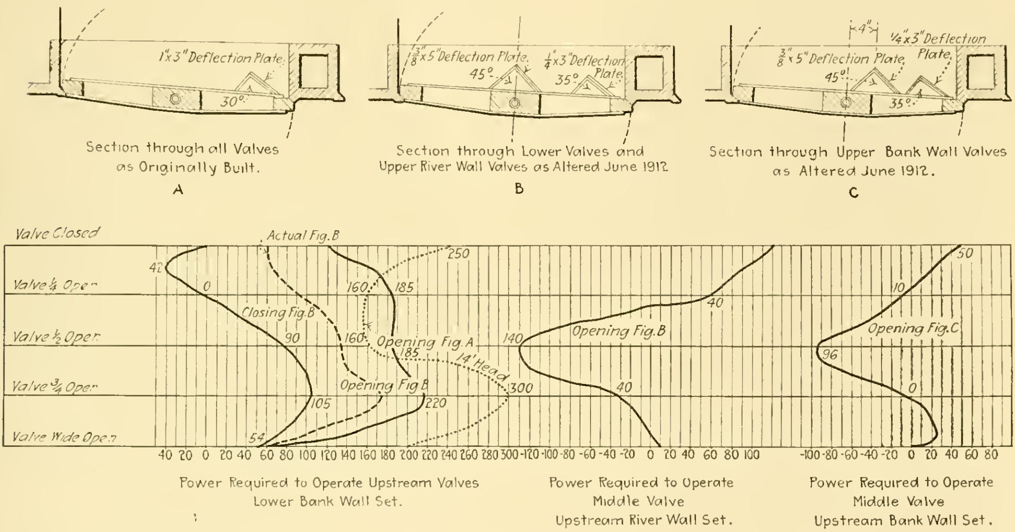



Fig. 7 Butterfly Valve Experiments

to the opening of the valve next down stream. *Second,* the valve divides this stream moving into the valve opening and the portion of the current down stream of the valve is deflected by the valve body. The eddy motion thus caused may produce a reverse pressure on the inmoving or down stream side of the back plate of the valve near the culvert floor, this also tending to close the valve.

Various deflection plates or partitions were installed and in August, 1911, a series of tests was made to ascertain the effect of these various arrangements of deflection plates applied to butterfly valves of the kind above described. The tests were made on a quarter side valve carefully built of steel.

A comparison of the curves of the first diagram of Fig. 7 for a lower valve with those for an upper valve (B and C) shows a material difference in the curves, which is due to the absence of backwater in the upper culvert. This again shows that the sheet of water entering when the valve is "cracked" is deflected free of the inturning half of the lift by the second deflection plate, Fig. B, which causes the valve to slam open. As a result of this test, it was decided to add to all butterfly valves then in service, in addition to the 3-in. deflection plate originally provided, a second plate 5 in. wide, screwed to the back of each valve with horizontal angle of 45 deg. between them and with the outer edge 4 in. upstream from the center line of the back plate, as shown in "C," top Fig. 7. The additional deflection plate, combined with certain partitions between the valves, has made it possible for one operator to open to normal position the three valves of one side simultaneously and under full heads up to 21 ft. (4 pp., 4 plates, *ed.*)

## UTAH SOCIETY OF ENGINEERS

*Vol. 1, no. 8, August 1915, Salt Lake City, Utah.*

The Relation of Stream Gaging to the Science of Hydraulics, C. H. Pierce and R. W. Davenport

The article represents a general discussion of the modern tendencies in the development of the science of hydraulics as affected by the work done in stream gaging, especially in connection with various irrigation problems in the United States and also by the United States Geological Survey.

The author believes that methods for the measuring of discharge, such as the use of salt or other chemicals, or the use of a diaphragm in open channels of uniform cross-section, are likely to become increasingly valuable, but as with the use of the weir, they probably will not be universally applicable as means of measurement. The current meter is undoubtedly founded on the right principle and it is hardly conceivable that it will be superseded.

A study of the evolution of stream gaging shows the important part played by empirical developments together with scientific research, and it is even conceivable that in time the same results might have been obtained through empirical processes alone. This fact is illustrated by some features of the present method of stream gaging. The observations of velocities at six-tenths and two-tenths of the depth have resulted from a large number of experiments, but it is now a well known fact that these methods are supported by the form of the vertical velocity of curve, which is that of the parabola; in fact, the author criticises somewhat the development of the present studies of stream gaging, in that possibly too much reliance has been placed on empirical methods and the advantages to be gained from scientific analyses have been given too little recognition.

Theoretical considerations embraced under the science of hydraulics, constantly appear as supplementary to the practical applications. For example, a thorough knowledge of Chézy's formula may often be of great practical use in analytical studies of stream flow data, although the field of direct application of the formula is limited.

The drainage investigations which have recently been undertaken in some of the Southern States for the purpose of reclaiming thousands of acres of rich agricultural lands afford an excellent illustration for the need of stream gaging of a high degree of precision. Many valuable experiments tending to increase the knowledge of hydraulic phenomena have been carried out in connection with irrigation work in the arid regions where, in some special investigations with comparatively small quantities of water, volumetric methods were used. In the work of the United States Reclamation Service, the science of stream gaging has been applied to a large number of problems, such as determination of friction losses in large size wood-stave pipe; values of the coefficient of roughness for different materials; proper coefficients to be used in computing discharge through gas; efficiency of pumps and turbines and economic size and cost of power plants for pumping water for irrigation.

The author comes to the general conclusion that a large amount of research is yet needed before hydraulics can become an exact accepted science, but the recent developments in stream gaging point to the possibility that this branch of hydraulics may in time reach a state of perfection such that all problems connected therewith may be solved with mathematical exactness and the term "probable error" be reduced to a rational quality. (8 pp., 1 fig., *g.*)

## CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles in the Survey.

## NECROLOGY

### R. PAUL STOUT

R. Paul Stout was born at Bethlehem, Pa., in 1869. He was educated at a private school at Audenried, at the Hill School of Pottstown, and later at Lehigh University, from which he was graduated in 1891 with the degree of Mechanical Engineer. During vacation periods, he served as a machinist in the shops of the Janesville Iron Works.

His first position after graduation was that of mechanical engineer with the Lehigh & Wilkes-Barre Coal Company at Audenried. He entered the employ of the Bethlehem Steel Company as assistant superintendent of the armor plate department in 1894, when the armor for the United States battleships *Brooklyn, Oregon, New York* and *Iowa,* and the Russian ships *Petropovlovsk, Admiral Siniavan, Admiral Oushakoff* and *Rostislav,* and also the first large armor plate vault for the Philadelphia Savings Fund Society, was being manufactured by the company. During this time, too, face-hardened armor was first manufactured in this country and the best Harveyized armor in the world up to that period was developed at the Bethlehem plant.

In August, 1897, on the formation of the Bethlehem Company's ordnance department, Mr. Stout was transferred to that department and two years later he assumed charge of the development of the first piece of ordnance mechanism of its own design which the company sold. Under Engineer of Ordnance Lieut. Meigs, he had charge of all the experimental and development work in this department until September, 1910, when he himself was appointed Engineer of Ordnance, which position he held up to the time of his death. Within his period of service in this capacity, the company secured the largest naval ordnance order placed in this country, in the complete ordnance equipment and armor for the Argentine battleships *Moreno* and *Rivadavia,* and it was in the last two or three years that the company attained its present position in the manufacture of all kinds of ordnance and munitions.

Mr. Stout was elected to membership of the Society, member grade, in 1906. He was also a member of The Franklin Institute. He was killed on August 25 as the result of the accidental detonation of a high explosive shell.

### JOHN CHARLES WILLIAM GRETH

John Charles William Greth was born in Buffalo, N. Y., in 1874. He attended the public schools of that city and was graduated from the Buffalo Central High School in 1893. In the same year he entered Cornell University and was graduated in 1897 with the degree of Mechanical Engineer. After graduation he began his engineering work by installing and operating for a few months a power plant at a summer resort on Lake Erie. From 1898 until 1902 he successively installed pumping machinery, designed special machinery, operated a power plant and installed and operated refrigerating and ice making plants.

In 1902, he entered the service of Wm. B. Scaife & Sons Co., Pittsburgh, Pa., as manager of the water softening and purification department, and from that year until his death his time was devoted to the development of apparatus and methods for the softening and purification of water for all purposes.

Mr. Greth took out sixteen patents on improvements in water purifying apparatus, several of which embodied radical features. He occupied a leading position in the field of water purification and his forceful presentation contributed very materially to the advancement of the science and application of water purification for industrial use.

Mr. Greth was the author of a number of articles on water purification published in the engineering press and he read several papers on the same subject before various engineering societies. He was recognized as an expert in water purification by engineers and chemists and his integrity gained for him a wide circle of friends.

He was a member of the American Society of Civil Engineers, the American Institute of Chemical Engineers, Engineers Society of Western Pennsylvania, and of the American Chemical Society.

He was elected a member of the Society in 1907. He died at Gibsonia, Pa., on August 7 after a short illness.

### HERBERT GRAY TORREY

Herbert Gray Torrey was born in New York in 1839. He was educated in the College of the City of New York, from which he was graduated in 1860. He became the assistant of his father, John Torrey, who was the first chief assayer in the U. S. Assay Office in New York City, and he succeeded his father at the latter's death in 1873. He served as chief assayer until 1910, when he went into private practice, becoming president of H. G. Torrey and Co., assayers and metallurgists; he retired in 1912.

Mr. Torrey was also a consulting chemist, a specialist on alloys and a government expert in textile fabrics and an examiner of mines. He maintained a private metal shop at Stirling, N. J., manufacturing magnolia metal. He invented Torrey metal, an anti-friction alloy.

He was a member of the Society of the Cincinnati, the American Institute of Mining Engineers and The Franklin Institute. He became a life member of the Society in 1890. He died at his home at Stirling on August 29.

## PERSONALS

Gilbert R. Haigh has recently become associated with A. D. Wilt, Jr., of the Wilt Twist Drill Company of Walkerville, Ontario, Canada, in drill manufacture and industrial engineering.

Carleton Wandel, formerly associated with the New York Central and Hudson River Railroad, West Albany, N. Y., has accepted a position with E. W. Bliss Company of Brooklyn, N. Y.

C. R. Cady has accepted a position with Smith, Hinchman and Grylls, Detroit, Mich., as industrial engineer. He was until recently affiliated with the Celfor Tool Company of Buchanan, Mich.

William J. Sweetser, until recently assistant professor of mechanical engineering at Case School of Applied Science, Cleveland, O., has been appointed professor of mechanical engineering at the University of Maine, Orono, Me.

Emile J. Bayle has resigned his position as general engineer of the American Beet Sugar Company, Denver, Colo., to accept the position of production manager for the Aluminum Castings Company, at their Detroit plant.

James A. Hall has resigned his position as draftsman with the Link-Belt Company, Philadelphia, Pa., to take up the assistant professorship in mechanical engineering at Brown University, Providence, R. I.

H. Owesen has severed his connection with the Standard

Steel Car Company, Butler, Pa., as assistant chief draftsman of the die department, and has accepted a position with the Carnegie Steel Company, Homestead, Pa.

William E. Moore has resigned his position with the West Penn Traction and Water Power Company Properties, Pittsburgh, Pa., as vice-president and general manager, and will open offices in Pittsburgh as consulting engineer.

Arthur F. Murray, formerly associated with the International Steam Pump Company, St. Paul, Minn., has become connected with The Blake and Knowles Steam Pump Works, East Cambridge, Mass., as equipment engineer.

M. William Ehrlich has severed his connections with Cole, Ives and Davidson, after two and one-half years of service, and has taken up the duties of editing *Electrical Engineering*, a monthly paper devoted to the field of electric practice, with headquarters in New York City.

Burt D. Thompson has become associated with the Curtiss Motor Company of Hammondsport, N. Y., as production manager. He was until recently foreman of machine shop of the National Twist Drill and Tool Company, Detroit, Mich.

William T. Clark has accepted a position with the Automatic Machine Products Company, Brooklyn, N. Y., as general manager. He was formerly connected with the Enterprise Manufacturing Company of Pennsylvania, Philadelphia, Pa., as manufacturing manager.

G. D. Bradshaw, steam engineer of the Cambria Steel Company, has tendered his resignation and on October 1 will enter business for himself at Pittsburgh under the firm name of Andrews-Bradshaw Company. Mr. Bradshaw has been in the Steam Engineering Dept. of the Cambria Steel Company for the past five years. Prior to that time, he was employed by the Indiana Steel Company at Gary for one year, and by the Illinois Steel Company of Chicago for five years.

R. S. Farr has been appointed instructor in mechanical drawing and design at the Towne Scientific School of the University of Pennsylvania, Philadelphia, Pa.

Frederick H. Moody has left for active service as an infantry captain, second in command of No. 4 company, 83rd Battalion, Canadian Expeditionary Force. He has been nine years in the Canadian Militia, five years in the ranks in the Engineers, and four years as a commissioned officer in the Queen's Own Rifles of Canada.

Louis J. Illmer Jr. has accepted a position as chief engineer of the Lake Heat Engine Company of Bridgeport, Conn., developing Mr. Simon Lake's inventions and ideas as applied to Diesel engines for submarine drives.

William F. Turnbull has been appointed instructor in mechanical drawing and design at the Towne Scientific School of the University of Pennsylvania, Philadelphia, Pa.

## EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

### POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. In sending applications stamps should be enclosed for forwarding.*

0244 Machine shop foreman between 25 and 35, capable of handling about 50 men. Experience with agricultural implement parts preferred. Salary $110 to $125. Location Pacific Coast.

0245 Storekeeper between 35 and 40, with at least three years' experience in charge of store department. Conscientious man required. $125. Location Pacific Coast.

0246 In engineering department for young college graduate M.E. with one or two years' experience in shop practice or in time study. Salary according to qualifications. Location Maine.

0248 Large concern in Central New York State, manufacturing pumping machinery, has vacancies for technical graduates interested in taking student's course in shop and testing department. Compensation 25 cents per hour for 55 hour week. Work leads directly to sales department where advancement depends on ability shown. Reply by letter.

0249 Draftsman, machine tool worker, jigs, dies, etc. Some shop experience preferred. Give age, experience and salary expected. Location East Chicago, Ind.

0250 General electrician to take charge electrical department of cement plant. To be working foreman when necessary and superintend three electricians and two motor attendants. Repair, construction and transmission work necessary. Salary $150. Location Southern States.

0251 Mechanical engineer experienced in designing and building special machinery for manufacture of paper goods and printing, to take charge of drafting room and large machine shop of 1000 machine capacity. Splendid opportunity for right man. Apply by letter, stating experience and expectations.

0253 Capable machine tool designer with 15 or 20 years' practical experience in shop and drawing room, to design lathes and turret machinery from 1500 to 4000 lb. Location New York State.

0255 A state university needs two competent instructors in mechanical engineering. Excellent practical and preferably teaching experience desired. One in machine design, other in mechanical engineering laboratory practice and steam engineering. Send full statement of training and experience, with list of references and recent photograph. Salaries according to qualifications. Location Central States.

0256 Designer and constructor of steam and centrifugal pumping machinery. Man who can take charge of department in small factory. $35 to $40 per week, with possibility of advancement. Location Michigan.

0259 Large casualty company has opening in its steam boiler and flywheel insurance department for special agent and solicitor. Insurance experience unnecessary and the company would be glad to receive applications from men with selling experience in mechanical lines and familiar with steam plant operation. $100. Location New York.

0261 Two or three first class mechanical draftsmen, competent to lay out and develop plans in detail of wood and steel brake construction. Location Scranton, Pa.

0265 Thoroughly practical mechanic who has had considerable shop experience, and has executive ability. Prefer young man. Location Ohio.

0268 Designer of crushing, conveying, elevating and mining machinery. Salary $40 per week. Location New York.

0269 Junior draftsman on same work as 0268. Salary $25 per week. Location New York.

0270 Combustion engineer, with practical and technical experience with boilers, stokers and auxiliaries. Knowledge of boiler and refrigerator testing, power plant work. Give references and salary expected. Location New Jersey.

0271 Wanted, a mechanical engineer salesman, by firm with business in various parts of Spanish America, handling mining, agricultural, power plant and railway machinery. Must be a native of the U. S. and a graduate mechanical engineer with degree from a U. S. college or university. Not under 30 nor over 45. Ability to write specifications on pumps, steam power plant equipment and locomotives; successful experience as salesman; good address and appear-

ance essential. Must speak and write Spanish well. Apply by letter.

0274 General superintendent to develop machine factory; thoroughly practical and responsible and in position to systematize special automatic machines. Knowledge of paper products and German language essential. Salary according to qualifications. Location Hoboken, N. J. Apply through Society.

0277 Recent graduate with practical experience and adaptability for research work required as assistant to testing engineer. Salary $80 to $100 to start, depending upon ability and experience. Location New Jersey.

## MEN AVAILABLE

*The published notices of "men available" are made up from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.*

J-269 Student member, 1915 Columbia University graduate M.E., desires a position in or around New York which offers an opportunity to start in the engineering profession. Salary to start secondary consideration.

J-270 Ordnance engineer, member, M.E. degree 1913, age 35, married, fourteen years' experience, five and one-half years in army ordnance department, three and one-half years captain of coast artillery, completed ordnance school of application, familiar with electrical machinery and gas engines, commended for management and also familiar with efficiency systems, desires administrative position in development of military manufactures.

J-271 Designer of automatic machinery and general engineering is open for position.

J-272 Member, graduate engineer, age 35, American, capable designer, practical foundry and shop man, experienced in modern production, methods and management, has had broad engineering experience in Europe and America as mechanic and executive in design and manufacture of engines, heavy machinery, machine tools, automatic machinery and light grade specialties, desires position as chief engineer, superintendent, manager or assistant. Location immaterial, salary commensurate with position.

J-273 Mechanical engineer, five years' practical experience in steam turbines, power plant equipment and layouts; also reinforced concrete and construction work. Future opportunity considered before salary. No preference to location. At present employed.

J-274 Member, technical graduate, age 34, experienced in editorial and publicity work, can write forcefully and with exceptional ability in attractive arrangement of copy, desires position as assistant to advertising manager.

J-275 Member, mechanical engineering graduate of Worcester Polytechnic Institute, age 26, two and one-half years' experience in engineering department of a large steel plant, wishes to make a change and become permanently connected with a New England company or firm where he can learn the business and become of value to it.

J-276 Graduate M.E., age 31, well posted on pumps and pumping machinery of all types, oil, gas and steam engines, drawing room and shop practice, sugar house work in Mexico and sales engineer in Brazil, desires permanent employment with reliable firm either in sales, office or shop. At present employed as salesman and expert on farm machinery.

J-277 Mechanical electrical engineer, age 32, married, with five and one-half years' experience on the design and installation of all kinds of factory equipment, and the practical application of the principles of scientific management, desires a change. First class man on time study standardization and systematizing. Salary $2400.

J-278 Member, age 35, with an unusually thorough experience in rubber mill engineering, including developments, reports, designs, specifications and contracts for buildings, power requirements and manufacturing equipment, desires position with consulting engineer or large rubber mill. Salary $4000. At present employed.

J-279 Technical graduate, M.E., age 28, experienced in shop and drafting room, elevating and conveying machinery, desires position as draftsman or designer with good chance for advancement.

J-280 Junior member, Columbia graduate M.E., 1913, two years' experience in production and drafting department, desires position in New York with chance for advancement. At present employed.

J-281 Associate-member, age 33, with experience as sales engineer and in charge of sales in specified territory, of air compressors, refrigerating and pumping machinery, including layout and installing, desires position as local sales manager with headquarters in Chicago. Prefers to associate himself with manufacturer who is looking for a considerable increase in sales and needs a capable and conscientious representative to obtain such a result.

J-282 Associate-member, age 34, technical and practical training, specialized in manufacturing of cement, ten years' experience designing, building and operating crushing and cement plants, two years' selling experience, desires position as sales engineer with concern manufacturing machinery for cement and crushing plants, or accessories connected with the industry.

J-283 Member, age 32, married, who has held positions from shop errand boy to present position of general manager, wishes to become connected with large industry or undertaking; thoroughly acquainted with automobiles, has traveled extensively and has had charge of men for fifteen years. Would like to be assistant to general manager, but would consider any position that would make advancement posible. Willing to go anywhere but prefers New York, Detroit, Chicago or vicinity.

J-284 Associate-member, age 26, married, nine years' experience machine shop, foundry and general engineering practice. Has filled position of engineer inspector to large inspection bureau handling large government and private contracts comprising all kinds of mechanical construction. Desires change to avoid continual travel and wishes position as assistant engineer, superintendent or production engineer. Location immaterial.

J-285 Mechanical engineer, age 33, married, graduate of leading engineering college, twelve years' practical experience, chiefly in the manufacture of boilers and general plate work in engineering and executive positions. Would be valuable as manager, assistant manager or chief engineer. At present employed.

J-286 Associate-member, broad experience in operating, thoroughly versed in power plant economics and qualified to design power houses, or operate existing plant to obtain maximum efficiency, desires position as chief engineer of power plant. At present in charge of power end of large automobile factory. Speaks Spanish.

J-287 Associate-member, age 27, married, Cornell, M.E., five years' experience in construction and operation of hydro-electric plants, large part of the time executive in responsible charge, desires position. Now employed in Utah but desires residence in lower altitude.

J-288 Junior member, M.E., age 27, seven years' experience in design of gasoline and kerosene engines, jigs, tools, power plant installations, and general equipment, desires position with reliable manufacturing or engineering concern.

J-289 Associate-member, Cornell M.E., broad engineering experience capable of handling men, now holding manufac-

turing executive position desires change. Would also consider position which requires knowledge of sheet steel for various requirements.

J-290 Member, technical education and fourteen years' general engineering experience, perfectly familiar with design, construction and operation of plants manufacturing cement, coal mining and coking plants; has made an especial study of elevating and conveying machinery in connection with cement making and coal handling. Has held positions as chief draftsman, mechanical engineer and superintendent. Now employed but to avoid traveling desires to get in touch with large company where experience and ability may gain him a permanent position.

J-291 Experienced designer with broad experience in metal-working machinery and tools wishes to get in touch with concern which would undertake the manufacture of new line of medium sized machines. Location middle west.

J-292 Associate-member, fourteen years' experience in operating and superintending power plants, at present holding position as chief engineer of several plants, desires similar position or one as erecting superintendent, foreman or maintenance man. Position preferred where there is an opportunity to work up to executive position.

J-293 Junior member, Columbia graduate, experienced in design and construction work, desires permanent position in New York or vicinity. Prefers commercial or sales work. At present employed.

J-294 Associate-member, age 41, Lehigh University graduate in mechanical engineering, with eighteen years' varied experience in mechanical, electrical and civil engineering lines, involving design, supervision and direct charge of construction work, plant operation, purchasing, reports, etc., all in connection with electric railways, lighting plants, power and industrial plants, wishes an executive position as manager, superintendent, or sales engineer, with large field and responsibility. At present employed. Southern location preferred.

J-295 Member, graduate of United States Naval Academy, age 33, married. At expiration of six years' active service in the Navy, resigned honorably; has been several years in the employ of large corporations in executive position, desires operating executive position, or other connection, where education, experience and capacity for work count. Location immaterial.

J-296 Member, mechanical engineer, age 35, graduate of Worcester Polytechnic Institute, twelve years' practical experience in design, construction and operation of machinery and manufacturing equipment for power plants and machine shops, also building construction. Ten years with present company. Has had broad experience in work of brass and iron foundries, grinding, polishing, japanning, plating, forging, hardening and machine departments, also in plumbing, millwright, carpenter, electrical and plant work. At present in charge of engineering department for large concern.

J-297 Member with fifteen years' experience in the development and application of pumping machinery would like engagement with large industrial works. East preferred.

J-298 Member, technical man with twenty years' experience in designing, building and general engineering work, capable of managing and assuming responsibility, energetic, ambitious and reliable, desires position with well established company. Location preferred, eastern states.

J-299 Member, age 37, graduate Massachusetts Institute of Technology, thoroughly experienced in the design, development and manufacture of special automatic machinery, dies, tools, electrical devices and fittings of all kinds, furnaces, electro-galvanizing, etc., has taken out a large number of patents, A1 executive, knows what economy in production means and how to obtain it. At present chief engineer of large corporation, but desires to change.

J-300 Junior member, age 26, Swarthmore graduate, at present superintendent of factory making fire apparatus, familiar with costs, brass foundry and forge shop production, desires position in engineering department of concern manufacturing standardized products. Salary $150. Location eastern states, preference, Philadelphia.

J-301 American Member of the Society, technical graduate who has resided in China for the past five years, with wide experience with machinery, would like to get in communication with American firms wishing to open branch manufacturies in China or who would like an agent to represent them in that country.

J-302 Graduate mechanical and chemical engineer with four years' teaching, and various power plant and oil mill experience, desires responsible position with some mechanical-chemical industry. At present employed.

J-303 Technical graduate, M.E. and C.E., with wide experience in teaching and consulting engineering work, wishes position as chief engineer or professor of mechanical engineering in university of good standing. Speaks French. Salary $4000.00. Is open for immediate engagement.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Society of Mechanical Engineers. Transactions, vol. 36. *New York, 1915.*

Association of Railway Telegraph Superintendents. Proceedings, June 22-25, 1915. *Milwaukee, 1915.* Gift of Association of Railway Telegraph Superintendents.

Association of Transportation and Car Accounting Officers. Proceedings, June, 1915. Gift of Association.

Bureau of Railway Economies. List of references on the use of Railroads in War. *Washington, 1915.* Gift of Bureau of Railway Economics.

Carnegie Endowment for International Peace. Year Book, 1915. *Washington, 1915.* Gift of Carnegie Endowment for International Peace.

Connecticut Society of Civil Engineers. Papers and Transactions for 1914 and Proceedings of the 31st Annual Meeting, Feb. 9-10, 1915. *New Haven, 1915.* Gift of Connecticut Society of Civil Engineers.

Graphic Methods and the Presentation of this Subject to First Year College Students, M. F. P. Costelloe. Reprint from The Nebraska Blue Print, Apr., 1915. Gift of Iowa State Drainage Association.

Index of Papers and Subjects Discussed by Railway Clubs from May 31, 1914-May 31, 1915. Gift of New York Railroad Club.

Iowa State Drainage Association. Proceedings of Eleventh Annual Meeting, 1915. *1915.* Gift of Association.

München. Königliche Bayerische Technische Hochschule Jahresbericht, 1913-14. Gift of Königliche Bayerische Technische Hochschule in München.

——— Programm., 1914-15.

New Jersey. Public Utility Commissioners. Fifth Annual Report, 1914. *Trenton, 1915.* Gift of New Jersey Public Utility Commissioners.

New Orleans, La. Sewerage and Water Board. Thirtieth Semi-Annual Report. *New Orleans, 1914.* Gift of Sewerage and Water Board.

Philadelphia. Department of Public Works. Annual Report, 1913. *Philadelphia, 1913.*

——— Highways. A problem in municipal housekeeping.

——— Plain talk about public works. *Philadelphia, 1914.* Gift of A. S. M. E.

Properties of Steam and Ammonia, G. A. Goodenough. *New York. John Wiley & Sons. 1915.* Gift of Publisher. Price $1.25.

These tables are based on formulae published in Bulletins 66 and 75 of the Engineering Experiment Station of the University of Illinois. They give the thermal properties of steam saturated and superheated and ammonia, with the necessary logarithms and conversion tables. W. P. C.

Railway Library and Statistics, Slason Thompson, 1914. *Chicago, 1915.* Gift of author.

Royal Societies Club. Rules, by-laws, list of members. *London, 1914.* Gift of A. S. M. E.

Special Libraries, R. H. Johnston. Reprint of Manual of Library Economy, Chapter VIII. *Chicago, 1915.* Gift of Bureau of Railway Economics.

Street Paving and Maintenance in European Cities. A Report by H. W. Durham. *New York, 1913.* Gift of Ralph Folks, Commissioner of Public Works, Borough of Manhattan.

Theory and Experiments in Following Plane Machines. Charles R. Wittemann. *1915.* Gift of Aeronautical Society of America.

Tufts College. Announcement of the Engineering School 1915-16. *Tufts College, 1915.* Gift of Tufts College.

Valves and Valve Gears, F. DeRonde Furman. vol. II. *New York, John Wiley & Sons, 1915.* Price $2.00. Gift of publisher.

This volume treats of valves for gasoline, gas and oil engines, and is illustrated by detail drawings. W. P. C.

### GIFT OF MRS. DAVID N. MELVIN.

Mrs. Melvin has presented to the Society all of the books forming the technical library of her late husband, a member of the Society since 1880. The collection, about 500 volumes, comprises a set of Engineering and Van Nostrands Eclectic Magazine, a set of the Transactions of the Society, and a large collection of modern textbooks.

### GIFT OF C. W. RICE

Institution of Civil Engineers. Descriptive Pamphlet of New Building. Jan. 1914.

Land Grant College Engineering Organization. Proceedings Jan. 24, 25; Nov. 11-14, 1913.

La Vie Internationale. Tome V, nos. 1-2. *Bruxelles, 1914.*

### EXCHANGES

Brooklyn Engineers' Club. Proceedings for 1914. *Brooklyn, 1914.*

Institution of Mechanical Engineers. Proceedings 1915. Jan.-June. *London, 1915.*

### TRADE CATALOGUES

Bristol Company. *Waterbury, Conn.* Bristol Recording Instruments, Panama-Pacific Exposition.

Cleveland Twist Drill Co. *Cleveland, Ohio.* Drill Chips, August 1915.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts, August, 1915.

Leschen, A. & Sons Rope Co. *St. Louis, Mo.* Leschen's Hercules, August 1915.

Pusey & Jones Co. *Wilmington, Del.* Super-Calendar, August 1915.

Valley Iron Works Co. *Appleton, Wis.* The Beater, August, 1915.

Walworth Mfg. Co. *Boston, Mass.* Walworth Log, August 1915.

## UNITED ENGINEERING SOCIETY

A B C of Iron and Steel, A. O. Backert. *Cleveland, 1915.*

American Table of Distances, specifying distances to be maintained between storage magazines for explosives and inhabited buildings, public railways, public highways. (Pamphlet no. 2, Institute of Makers of Explosives). *1914.* Gift of Institute of Makers of Explosives.

Brassey's Naval Annual, 1915. *London, 1915.* (Purchase.)

Case Hardening of Steel, Harry Brearley. *London, 1914.*

Chlorine Control Apparatus for Water and Sewage Purification. Gift of Wallace & Tiernan Co.

Collected Diplomatic Documents Relating to the Outbreak of the European War. *London, 1915.* Gift of Carnegie Endowment for International Peace.

Engineering Directory, pts. I-II, 1915. *Chicago, 1915.*

Evidence and Documents Laid Before the Committee on Alleged German Outrages. *New York.* Gift of Carnegie Endowment for International Peace.

Graphical Representation of Certain Vital Features of the Natural Gas Industry in the United States, prepared by S. S. Wyer. *Columbus, 1915.* Gift of author.

La Marbrerie. By M. Darras. *Paris, 1912.*

Lloyd's Register of Yachts, 1915. *London, 1915.*

Moody's Manual of Railroads and Corporation Securities. Vol. II,—Industrial and Public Utility Section. 1915. *New York, 1915.*

New York Times Index. Vol. II, April-June 1915. *New York, 1915.*

Osborn's Tables of Moments of Inertia and Squares of Radii of Gyration. ed. 5. *Cleveland, 1905.*

Purchasing, C. S. Rindsfoos. *New York, 1915.*

Rules for Handling, Storing, Delivering and Shipping Explosives (Pamphlet no. 5, Institute of Makers of Explosives). 1914. Gift of Institute of Makers of Explosives.

Safety and Short Trains, Marcus A. Dow. Gift of author.

Shrapnel and other War Material. A reprint of important articles presented in the "American Machinist" from January to June 1915. *New York, 1915.*

Standard Handbook for Electrical Engineers. Ed. 4. *New York, 1915.*

Standard Storage Magazines, recommended by The Institute of Makers of Explosives. Pamphlet no. 1. *Chicago, 1914.* Gift of Institute of Makers of Explosives.

Technisches Auskunftsbuch, 1915, Hubert Joly. *Leipzig, 1915.*

Theory and Practice of Ore Dressing, E. S. Wiard. *New York, 1915.*

### TRADE CATALOGUES

Carnegie Steel Co. *Pittsburgh, Pa.* Axles and Forgings, Ed. 6, 65 pp.; Structural Beams, Ed. 2, 12 pp.

Koehring Machine Co. *New York City.* Description of Koehring Mixers.

Siemens Schuckert Werke. *Berlin, Germany.* Drehstrom Fordermaschinen mit Widerstands Regelung, 45 pp.; Elekstrische Fördermaschinen, 27 pp.; Winding Engines, 44 pp.

Walden's A B C Pocket Book of the Paper and Stationery Trades, 1912. *New York, 1912.* Gift of Wm. Harper Davis.

Washburn Crosby Co. *Minneapolis, Minn.* Wheat and Flour Primers, 20 pp.

## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

John A. Brashear, *President* Calvin W. Rice, *Secretary*

Finance Committee, R. M. Dixon

House Committee, S. D. Collett

Library Committee, Leonard Waldo

Committee on Meetings, J. H. Barr

Committee on Membership, W. H. Boehm

Publication Committee, C. I. Earll

Public Relations Committee, M. L. Cooke

Research Committee, R. C. Carpenter

Committee on Constitution and By-Laws, Jesse M. Smith

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal.

LOCAL MEETINGS

*Atlanta:* Earl F. Scott
*Boston:* H. N. Dawes
*Buffalo:* David Bell
*Chicago:* H. M. Montgomery
*Cincinnati:* J. B. Stanwood
*Los Angeles:* W. W. Smith
*Milwaukee:* L. E. Strothman
*Minnesota:* Wm. H. Kavanaugh
*New Haven:* H. B. Sargent
*New York:* Edward Van Winkle
*Philadelphia:* Robert H. Fernald
*San Francisco:* Frederick W. Gay
*St. Louis:* Edward Flad
*Worcester:* Paul B. Morgan

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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C 55. The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.


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## THIRTY-SIXTH ANNUAL MEETING

New York City, December 7 to 10

### PART LIST OF TOPICS TO BE DISCUSSED

Abrasive Wheels
Accident Compensation
By-Product Gas Producers
Chimney Proportions
Electric Elevators
Electrically-driven Tools
Engineering and the Executive
Fire Tube Boilers
Foundations
Heating Textile Mills
Higher Steam Pressures
High Vacuum Condensers
Hydraulic Power Plants
Locomotive Axles
Oil Engine Vaporizers
Orifice Gas Meters
Passenger Car Trucks
Prevention of Corrosion
Protection of Workers
Safety Methods
Steam Pipe Coverings
Strength of Stoneware
Turbines vs. Engines
Water Tube Boilers

### PART LIST OF AUTHORS OF PAPERS

Allen H. Babcock
Paul A. Bancel, Jun. Am. Soc. M. E.
J. S. Barstow
James E. Boyd
L. C. Brooks, Jun. Am. Soc. M. E.
Robert Cramer, Mem. Am. Soc. M. E.
F. W. Dean, Mem. Am. Soc. M. E.
Albert G. Duncan, Mem. Am. Soc. M. E.
Geo. H. Gibson, Mem. Am. Soc. M. E.
Hollis Godfrey, Mem. Am. Soc. M. E.
Ernest O. Hickstein, Jun. Am. Soc. M. E.
C. F. Hirshfeld, Jun. Am. Soc. M. E.
Louis Illmer, Mem. Am. Soc. M. E.
David Lindquist
Arthur H. Lymn
L. B. McMillan, Jun. Am. Soc. M. E.
Charles T. Main, Mem. Am. Soc. M. E.
Anatole Mallet, Hon-Mem. Am. Soc. M. E.
A. L. Menzin, Assoc-Mem. Am. Soc. M. E.
Mark A. Replogle, Mem. Am. Soc. M. E.
Roy V. Wright, Mem. Am. Soc. M. E.

For program of the meeting see page XV.

## MEETINGS OF LOCAL SECTIONS

*November* 4, *Buffalo, N. Y.* Subject: Multiplicity of Cylinders in Automobiles, by J. G. Vincent, Mem. Am. Soc. M. E. and Vice-President of the Packard Motor Car Company.

*November* 17, *New Haven, Conn.* Subject: Machine Tools.

*November* 23, *Philadelphia, Pa.* Subject: Industrial Safety, by William P. Barba, Mem. Am. Soc. M. E. and Vice-President of the Midvale Steel Company.

*November* 30, *Boston, Mass.* Subject: Gainful Pursuits open to Soldiers who have been injured, Frank B. Gilbreth.

# THE JOURNAL OF
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Volume 37 November 1915 Number 11


## INTERNATIONAL ENGINEERING CONGRESS

TWO hundred and forty-one papers were presented at the fifty-two sessions of The International Engineering Congress, 1915; and although the present international conditions have hampered somewhat the exchange of all but military engineering thought and experience, sixty-six of the papers contributed were by authors residing outside the United States. In addition to those from our own country, papers were received from Argentina, Australia, Austria, Canada, Chile, China, England, France, India, Italy, Japan, the Netherlands, Panama, Russia, South Africa, Sweden and Switzerland. It is interesting to note that forty-eight authors of papers coming from the United States were members of the Society.

### SUBJECTS OF THE CONGRESS

*Partial List of Subjects Included in the Papers Presented*

| | | |
|---|---|---|
| Agriculture | Forgings | Pulverized Coal |
| Alloys | Founding | Railways |
| Alloy Steels | Fuels | Refrigeration |
| Aluminum | Grinding | Rivers |
| Aviation | Heating | Safety |
| Automatics | Highways | Sanitation |
| Boilers | Hydraulics | Sewage Disposal |
| Bridges | Hydroelectrics | Ships |
| Cargo Handling | Illuminants | Signals |
| Castings | Iron | Steel |
| City Planning | Irrigation | Streets |
| Clay Products | Locomotives | Terminals |
| Compressed Air | Machine Tools | Testing Materials |
| Concrete | Management | Timber |
| Copper | Metallography | Tractors |
| Docks | Metal Working | Transit |
| Dust Prevention | Metallurgy | Tunnels |
| Economics | Mining | Turbines |
| Education | Motion Study | Utilities |
| Electrolysis | Navigation | Vehicles |
| Electric Motors | Ore Dressing | Waterways |
| Engines | Ordnance | Water Supply |
| Fire Protection | Panama Canal | Water Wheels |
| Flood Control | Power Stations | Welding |

#### CONCEPTION AND ORGANIZATION

The Congress was conceived in 1911 when a meeting of representatives of the American Society of Civil Engineers and The American Society of Mechanical Engineers recommended that engineers from the great associations of the world be called together in 1915 to participate in the celebration of the completion of the Panama Canal. A further conference in 1912 led to the formation of plans to hold the Congress in conjunction with the Panama-Pacific International Exposition, 1915. The enterprise was organized and conducted under the auspices of the American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, The Society of Naval Architects and Marine Engineers, and The American Society of Mechanical Engineers. Major General Geo. W. Goethals, the builder of the Panama Canal, was elected Honorary President and nineteen Honorary Vice-Presidents were chosen. Besides its president and secretary, each of the organizing societies elected four representatives on the Committee of Management; the six representatives of the Society on the Committee were Dr. John A. Brashear, Calvin W. Rice, Chas. T. Hutchinson, Thos. Morrin, T. W. Ransom and C. R. Weymouth. Dr. Wm. F. Durand served as Chairman of the Committee of Management; W. A. Cattell as Secretary-Treasurer, and E. J. Dupuy as Executive Secretary. There were six permanent sub-committees of the Committee, as well as six special sub-committees, taking care of the administrative and executive details of the organization.

#### MEMBERSHIP

To secure for those engineers coöperating in the Congress a permanent record of its proceedings, a plan of membership by subscription was inaugurated, and 3082 enrollments were made, 816 of which were from foreign countries. Each subscriber received the right to participate in the deliberations and privileges of the Congress, and the entitlement to a volume reporting the general proceedings of the Congress and containing indexes and digests of other volumes. and one volume of the transactions.

### THE CONGRESS

The Congress opened with a general session in the main hall of the Auditorium Building, Civic Center, San Francisco, on Monday, September 20, at 10 a. m. An address of welcome was delivered by Hon. James Rolph, Jr., Mayor of San Francisco, and other speakers were Maj. Gen. Goethals and the Honorary Vice-Presidents present, as well as Chas. C. Moore, President of the Panama-Pacific International Exposition.

The afternoon of the first day was devoted to a general session on the Panama Canal, six papers being presented, including an Introduction by Maj. Gen. Goethals. There followed during the six days of the Congress, four sessions on Waterways, four on Irrigation, five on Municipal Engineering, five on Railway Engineering, five on Materials of Engineering Construction, six on Mechanical Engineering, three on Electrical Engineering, three on Mining Engineering, five on Metallurgy, seven on Naval Architecture and Marine Engineering, and four sessions devoted to miscellaneous topics including Aviation, Refrigeration, Agricultural Engineering, Engineering Education, and Heating and Ventilation.

The total registration at the Congress during the week was 750. Foreign members and delegates attended from Austria, Australia, Canada, Germany, Switzerland, China, Cuba, France, Guatemala, Japan, Mexico, the Netherlands and Sweden.

### THE PAPERS

A complete list of titles of the papers and their authors was included in the full program of the sessions of the Congress published in the September issue of The Journal. The papers covered practically every field of engineering art and the general theme of each was to review recent progress and development in its particular subject and outline the tendencies of present effort. To several of the papers were appended bibliographies, making them a valuable index to the literature of current engineering practice. As members of the Society may be interested in the contributions of their fellow-members, brief synopses of these particular papers are given below; these are listed in the same order as in the program of the Congress, and under the same heads.

The abstracts are taken from the prints of the advance papers given out at the meetings.

## BRIEF ABSTRACTS OF PAPERS BY MEMBERS OF THE SOCIETY PRESENTED AT THE INTERNATIONAL ENGINEERING CONGRESS

### WATERWAYS

Hydraulics of the Locks of the Panama Canal, R. H. Whitehead

This paper discusses the arrangement of valves and culverts and expectation of the design of the Canal locks; observed characteristics of the system and importance of good distribution; discharge through lateral culvert openings when filling locks, neglecting friction; recommendations for design of lateral culverts and their openings; friction losses; discharge through openings corrected for losses; recommendation for total lateral culvert distribution; determination of time equation of flow; filling and emptying curves for Pedro Miguel Lock; calculation of value of dynamic head for complex culvert systems; the rising-stem valves; miter gates and the force required to operate them; current in locks due to difference in salinity.

The Province of Waterways in the Internal Commerce and Development of a Country, Brig. Gen. W. H. Bixby

### IRRIGATION

Economic Advisability of Irrigation, Dr. F. H. Newell

This paper is an exposition of the present condition of development of irrigation practice and an indication as nearly as may be of the principal economic reasons why irrigation has been and should be practiced. It includes a consideration of the causes which have led to the present delay in entering upon or completing large works and indicates some of the lines along which further progress may be expected.

### MUNICIPAL ENGINEERING

The Disposal of Suspended Matters in Sludge, Rudolph Hering

The paper is a discussion of the treatment of the liquid refuse of a city, with special reference to securing healthful results and preventing nuisances from the suspended matter contained in refuse. While it has been known for a long time that inoffensive decomposition of sewage can be secured by efficient aeration, agreement does not yet exist as to the most effective and economical way of applying and diffusing the air.

Public Utilities, Dr. Alex. C. Humphreys

"I am convinced that, under American conditions, the system of private ownership of public utilities is best for the citizens and the consumers," was an expression by Dr. Walton Clark in a minority report to the Commission on Public Ownership of the National Civic Federation. The author reiterates this conviction and devotes his paper to outlining the dangers of unreasonable regulation of utilities.

### RAILWAY ENGINEERING

Recent Locomotive Development, George R. Henderson

Within recent years there have been four distinct lines of advancement in steam locomotives—size, type, details and adjuncts. Utilizing the Mallet principle and adding a driving unit under the tender, we now have running a locomotive of 755,000 lb. adhesive weight and 160,000 lb. tractive force. Cast steel has probably exerted more influence on the design details of the locomotive than any other single item. The increased size and weight of locomotives has brought about

the addition of a number of special features; such are power reversing mechanisms, automatic fire door openers, pneumatic grate shakers, coal pushers and mechanical stokers.

Rolling Stock Other Than Motive Power, Arnold Stucki.

This paper deals with the car equipment used by the railroads of the U. S. and Canada and points out the improvements made during the last decade. These latter have been in the direction of safety and comfort of passengers, strength and efficiency of construction, efficiency in handling freight and in moving trains, and protecting freight. The introduction by the Erie Railroad in 1904 of the all-steel passenger car resulted in an evolution of passenger equipment, and tremendous progress has been made, too, by the use of steel in freight car construction.

The Floating Equipment of a Railroad, F. L. DuBosque

This paper describes in considerable detail the floating equipment of a railroad operating in New York Harbor, that employs 10 ferry boats, 31 tug boats, 7 self-propelled barges, 68 car floats, 71 covered barges, 71 derrick barges and 20 coal barges. The dimensions of the units are given, as well as descriptions and illustrations of them and the service in which they are employed.

## MATERIALS OF ENGINEERING CONSTRUCTION

Concrete Aggregates, Sanford E. Thompson

While uniform Portland cement is now manufactured at low cost, the other principal ingredient of concrete, the aggregate, has not been thoroughly standardized. Series of tests have been made, and are still in progress, for the clearer formulation of laws of concrete mixture. On account of the variation in strength of mortars made with different sands, sand and other aggregate should always be tested. Strength; permeability of the mortar and concrete; effect of different brands of cement; effect of frost action; effect of fire; characteristics of yield, density, chemical composition, mechanical analysis and amount of organic matter, are factors which should be considered.

Alloys and Their Use in Engineering Construction, W. Reuben Webster

The paper is more particularly devoted to the most extensively employed group of alloys of which copper is the base. It discusses the physical properties and characteristics of the brasses and bronzes and of the alloys containing copper, zinc, lead and tin, usually known as red brass and varying in strength, toughness, cost, color and machining qualities according to their composition.

Testing Full Size Members, Gaetano Lanza

This paper is retrospective, considering the meaning and scope of the term *Testing Full Size Members;* the importance of making such tests and the reasons therefor; the need for their performance on a systematic and well organized plan, so that the results obtained may be of the greatest value in engineering practice; an enumeration of the kinds of tests that have thus far received the most attention; a summary of the tests most needed, including a consideration of certain classes of tests concerning which comparatively little, and of others concerning which no progress has been made thus far, and a consideration of the value and possibilities of coöperation in making full size tests.

## MECHANICAL ENGINEERING

Recent Advances and Improvements in Founding, Thomas D. West

Since the introduction of electricity and compressed air as a motive power, improvements in the construction of foundries and their appliances have been steady and persistent. In keeping with the improvements for handling raw materials are those for mixing, melting, molding, core making and cleaning of castings. The production of ferrous and non-ferrous metals has been greatly assisted by chemical studies. The advancement in core making and molding has been due to the use of molding machines. The cleaning of castings by sand blasting, pneumatic and hydraulic tools, and electrical appliances has progressed. Labor saving appliances and the adoption of specializing have operated to improve materially the quality of castings.

Forgings from Early Times to the Present, C. von Philp

The different methods of producing forgings are hammering, pressing and squeezing, extruding, die-casting and bending. With the development of the steam hammer, with its valve gear, the size of forgings made by hammering has been greatly increased. The art of die forging has developed to such an extent that all kinds of intricate forgings that could never be thought of in the days of the early methods can now be made. Owing to the high speed of the modern hydraulic forging press, this can now compete with hammers in producing forgings of even comparatively small size. The extruding process is being used in the manufacture of pipes and wires of lead, shapes in brass, valves of high grade steel, rods, etc. Carburetors and instruments are being manufactured by the die casting method which has taken quite some time to develop. Bending was mostly employed for flanging boiler heads, but with the advent of the steel railroad car, bent forgings have been found more economical than structural shapes; they are also largely used in the shipbuilding trade.

Permanent Shops, Pacific Terminals—Panama Canal, H. D. Hinman and A. L. Bell

Machine Shop Equipment, Methods and Processes, E. R. Norris

The greatly increased feeds, speeds and depths of cut rendered possible by the use of Taylor and White's high speed steel made it necessary for the builders of machine tools to redesign their tools along heavier lines and with greater pulling power, and later to equip the machines with quick changing and automatic attachments to facilitate the handling between cuts. The paper considers special alloy steels, their composition, treatment, application and effect on machine shop practice; machining with edge tools; grinding as a final machining operation and electric driving for machine tools.

Machine Shop Equipment, Methods and Processes, H. F. L. Orcutt

This paper reviews the progress in American and European machine tools in the last fifteen years. As the most important improvements, the author selects single pulley drive, change gear boxes, independent motor drive, ball and roller bearings, speeding up idle movements, provision for cutting and cooling fluids, better lubrication, increased precision, chain drive and rigidity in design. He describes in detail recent advances in grinding, gear cutting and tooth finishing, and auto chucking machines.

Automatics, R. E. Flanders

From an early period lathes and, later, drilling machines have been provided with self-actuating feeds, and are thus automatic. As self-actuating feeds became the rule, something more was required to justify the use of the term, which has of late years only been applied to machine tools in which practically all the movements are self-actuating. The multiple spindle automatic screw machine is now firmly established, but the large multiple spindle automatic lathe is still a new venture. Milling machines, drill presses, gear cutting machines, grinding machines furnish other examples of automatics used in American machine shop practice.

The Internal Combustion Engine of the Year 1915. The Gas Power System. A Survey of Its Status in 1915, Prof. C. E. Lucke

After a fifteen-year period of close study of performance, design, construction and adaptation to service, the internal combustion engine and the gas power system occupy to-day a definite place in the scheme of industrial affairs and are so firmly established that they will never be replaced. Today the internal combustion engine is thermally more efficient, size for size and fuel for fuel, than the steam engine in any size in which it can be built, and the difference in fuel combustion is greater the smaller the size because efficiency of steam systems fall off very rapidly with decrease of size, while the internal combustion engine does not.

With the present state of knowledge on the properties of explosive mixtures and the distillation, vaporizing, gasification and combustion of fuels, the first fundamental step in the design of gas engines for specified performance is on a truly scientific basis.

Mechanism designers and power engineers are devoting attention to the mechanical perfection of apparatus operating on the two adopted cycles, the Otto and the Diesel, both of which have high enough efficiency characteristics both promised and realized for some time to come.

The Diesel Engine in America, Max Rotter

This paper includes historical and fundamental information regarding the Diesel, or high compression constant pressure oil engine, and the so-called semi-Diesel, or low compression oil engine. It compares the 2-cycle and the 4-cycle types. It considers the design details of Diesel engines, including fuel atomizing elements, cylinders and heads, pistons and accessories and lubrication. A part of the paper is devoted to the consideration of fuels and in another are mentioned and briefly described several Diesel type engines built in the United States. Typical indicator diagrams, both maximum and no-load, are given, enabling comparisons to be drawn, and the details described are well illustrated.

Water Wheels of the Pressure Type, Arnold Pfau

This paper is divided into eight chapters—theoretical definition of pressure wheels; previous and present art; applicability; classes, types and characteristics; description and selection of type; efficiencies and tests; accessories, and some general remarks and suggestions—a knowledge of the basic principles of water wheels is presumed. Wheels are classified according to the direction of flow of the water with reference to the shaft, as follows: radial outward discharge, diagonal outward discharge, axial discharge, diagonal inward discharge, radial inward discharge, and combined radial or diagonal inward axial and diagonal or radial outward discharge; a history of each of these classes is given.

The Francis turbine, the types of runners for which are now elaborately classified, has displaced all other types of reaction turbines and manufacturers now offer these turbines of large capacities for heads as high as 1000 ft. With a single runner, vertical shaft turbine, efficiencies can be obtained which exceed 90 per cent.

Water Wheels of Impulse Type, W. A. Doble

Safety Engineering, Frederick R. Hutton

Of the phases of the problem of industrial safety, the mechanical engineer is directly concerned with the prevention, by safety apparatus and otherwise, of accidents originating from the sudden injury to the body through the motor forces in industry. Complete safety at the origin of power calls for engine stops; lattice cages safeguard workers from the moving parts of engines. Belts and pulleys and chain drives are guarded with sheet steel or lattice, as are moving parts of machines and individual tools.

The forge and the rolling mill, the steel works and the blast furnace, the saw mill and the chemical process plant, the textile mill and the dye-house, the electric furnace and the power transmission line and switches—each offers its own problems and all have found their satisfactory safeguards.

Motor Vehicles; Utility Type, Arthur J. Slade

These are defined as self-propelled vehicles designed to be operated without rails, for the primary purpose of transporting materials, products, passengers or apparatus, especially for business purposes or for fire, profit, emergency work or special utility service; as distinguished from private personal use by the owner or renter for enjoyment or convenience.

The paper presents the results of the author's observation of the development, during the past decade, of the general types of commercial motor cars which have to any marked extent become standardized, and gives the present status as to features of design and application, and the tendencies of future development. The storage battery electric and the internal combustion engine driven vehicle are first considered, and special application of each or combinations of both are then referred to.

Compressed Air in the Arts and Industries, W. L. Saunders

The forcing of compressed air through the molten metal in the Bessemer converter, and the consequent decarbonizing action has made this method of steel making possible. To the forced draft in the boilers of vessels may be, in part, attributed the high power developments in restricted space for boiler capacity, as illustrated in naval practice, in torpedo boats, destroyers, etc. Bellows, rotary fans, blowing engines, rotary blowers, steam jet blowers, and other similar appliances are now used in the ventilation of mines, of buildings and generally in the removal of vitiated gases and in the supplying of gases and air for chemical purposes. Diving apparatus, bells, caissons and tunnel shields play a most important part in the field of engineering. Compressed air-operated locomotives are becoming generally employed. The employment of compressed air has solved the problem of braking railway trains. The pneumatic despatch tube as a conveyor has come into wide use. A pneumatic gun of 15-in. bore has been developed. The Whitehead torpedo is

driven by compressed air. In mines and quarries a large central compression plant has come to be accepted as the most effective means of providing power.

## ELECTRICAL ENGINEERING

The Effect of Hydro-Electric Power Transmission Upon Economic and Social Conditions, with Special Reference to the United States of America, Frank G. Braun

The stability of any civilization depends on the fact that it consumes less than it produces, and as with an increasing population, the most efficient methods must be employed for all operations, nature's naturally replenished sources of power must be used instead of consuming wood, coal, oil, etc.; and the most natural source of power is falling water, which nature is annually producing. This water power, converted into the electric form for distribution and supplied to electric appliances for conversion into the form desired, at the place desired, is the most efficient and convenient system imaginable.

The author expects to see central stations of 100,000 kw. and trunk transmission lines constructed to connect a large number of these stations throughout the continent, with branch substations and lines over the entire country. The prime movers will be limited to water wheels located at favorable water power sites and steam turbines at sources of cheap fuel, coal, oil or gas.

Electrical and Mechanical Installations of the Panama Canal, E. Schildhauer

Electric Welding, C. B. Auel

There are three clearly defined processes of electric welding—arc, incandescent and electro-percussive—each more or less limited to a certain field. The first includes the Zerener, Bernados and Slavianoff processes; the second, the La Grange-Hoho and the Thomson processes.

The arc processes are autogenous, in that welding can be accomplished without pressure, simply by allowing the metals to melt under the influence of the electric current, then to mix and unite as they cool; the incandescent and electro-percussive processes, however, invariably require pressure as a necessary adjunct to their successful accomplishment. The paper compares these processes and considers their applications.

The Electric Motor as an Economic Factor in Industrial Life, David B. Rushmore

The present highly developed civilization is dependent upon the utilization of the stored energy in our natural resources or upon the energy from the sun, either directly or through water powers; and the utilization of this energy on a broad scale has been economically possible only by the use of electricity.

Electricity is the most convenient form in which to transmit and apply energy, and the electric motor produces motion and torque at various speeds and in different directions.

The paper discusses the various types of electric-motor designs and gives examples of their applications. It outlines the fields of electric motor application.

The Influence of the Electric Motor on Machine Tools, A. L. DeLeeuw

The electric motor has influenced the machine tool beneficially along the following lines: better knowledge of the data governing the design of machine tools; greater possibilities in regard to power; closer control of a machine tool in regard to speeds, stopping, starting, etc.; flexibility of the use of machine tools, by making them portable and by making a better shop construction possible. The most marked and beneficial influence of the electric motor on machine tools has been the bringing into view of the lack of fundamental knowledge of machine tools, and it has opened up a new era—which may be called the scientific era—for the machine tool.

Effect of Electrolysis in Engineering Structures, Albert F. Ganz

The principal engineering structures which may be effected by electrolysis from stray electric currents are electric railway tracks, and iron or steel structures supporting these tracks; underground lead sheathed cable systems; underground piping systems and steel foundations of buildings, bridges, etc., and reinforced concrete structures. The paper give information, based on the writer's personal experience and on direct inquiry, illustrating cases of and remedial measures applied to affected structures.

## MINING ENGINEERING

The Valuation of Anthracite Mines, R. V. Norris

The problem of valuation of coal in the anthracite region in northeastern Pennsylvania is complicated by the rapid variations in the thickness and quality of the beds, by the numerous faults and still more numerous convulsions. The basins are traversed by endless anticlinals and synclinals, and within short distances good coal is changed to crushed and worthless dirt. The value of anthracite land has rapidly increased, until at the present time $3,000 per acre is considered only a fair price for good virgin coal land. In 1907 great advances were made in assessed valuation, and assessments imposed have been resisted in the courts; at the present time assessed valuations of $175 to $300 per foot-acre are attempted to be imposed.

Organization and Staff of Mining Companies, W. H. Shockley and R. E. Cranston

## METALLURGY

Improvements in Design and Construction of Modern Copper Plants, Chas. H. Repath

The rapid progress and development in mining and smelting in modern times has been due to the general development in all the arts and sciences and the increase in the general intelligence of the men who are engaged in this class of work. Mechanical appliances have been perfected and adapted to the problem of handling materials in every department and new machinery invented to do work that originally took large numbers of laborers. Nearly all large companies maintain experimental and testing departments, in charge of which are competent engineers and metallurgists, who are engaged constantly in the development of new processes and in perfecting the old ones that are used in the treatment of ores and in the conservation of the values that were previously wasted.

## METALLURGY

The Development of Electrolytic Copper Refining, Lawrence Addicks

Three distinct stages in the development of copper refining may be noted: early development; tonnage extension, and efficiency work. The first period ends with the development of mechanical ladling, general use of cranes for handling electrodes and the undertaking of the building of the Raritan Copper Works in 1898. The second period covers the next six years, which saw the creation of the first really large plants; and the third, the ten years just closed, with plenty of work yet in sight to put refining on a finished basis.

Both the series and the multiple processes have given relatively pure bullion and there is little to chose between them. However, the multiple process is much less sensitive to impurities and requires less skill in operation, and has been adopted by those later entering the refining business.

Surface Combustion (What is It?), C. E. Lucke

## NAVAL ARCHITECTURE AND MARINE ENGINEERING

River, Lake, Bay and Sound Steamers of the United States, Andrew Fletcher

This paper includes authentic drawings of the midship cross sections with scantlings, deck plans, elevations and a data sheet of general dimensions, draft, displacement, trial speed and motive power of a number of well-known and successful steamers of the United States. The steamers selected are of the steamboat type, with the exceptions of the turbine steamers "Yale" and "Harvard"; the steamer "Governor Cobb," the first Parsons marine-turbine steamer built in the U. S., and the turbine steamer "Belfast."

Special Types of Cargo Steamers for the U. S. Coast to Coast Trade Through the Panama Canal, Geo. W. Dickie

The character of the inter-coast trade demands a special type of vessel. The type demanded by part of the East-bound freight and all of the West-bound is not suitable for the economical transportation of lumber, which is the predominating part of the East-bound. The paper describes a vessel combining the good qualities of both the shelter-decker for general cargoes and the lumber steamer, and sacrificing the special functions of neither. Some of the objects are accomplished by making the lumber type of vessel deeper in the hold, adding a middle deck, carrying the hatches up through the deck load by making a continuous trunk for them, making in effect a partial shelter-deck type.

The Submarine, L. Y. Spear

Some Economic Fundamentals of Freight Handling, D. B. Rushmore

This paper gives a general outine, from an economic as well as an engineering standpoint, of the problems involved in freight handling, and discusses scientific methods of investigation, analysis and construction as the necessary means of solution of these problems. These problems have to do with the installation of mechanical apparatus in present terminals and for use with present ships, cars and warehouses; the development of ports and harbors and location and design of docks, terminals and warehouses; as well as the attempted standardization of package sizes. The field offers attractive possibilities for central station power loads and is one which will develop in the near future.

Fuel Oil, Ernest H. Peabody

The Application of Diesel or Heavy Oil Engines to Marine Propulsion, G. C. Davidson

The paper outlines the status of the Diesel engine as applied to marine propulsion today, and includes examples of present types of engines.

The Nobel Company was the pioneer in applying Diesel engines to marine purposes. Long before oil engines were used on ships in other countries, the Nobels had a fleet of Diesel-engine ships in operation in Russia. The Burmeister and Wein Company has been very successful in applying its heavy 4-cycle engines to merchant vessels.

## MISCELLANEOUS

Agriculture and the Engineer, J. B. Baldwin

A large part of agricultural production involves many mechanical operations not dissimilar to those used in the factory. Agricultural engineering embraces farm machinery, farm power, farm structures, rural sanitation, manufacture of agricultural products, drainage, irrigation and public roads. The first four of these relate more directly to the farm, and are naturally of more recent development, while the last three relate to the agricultural community and have reached a higher state of development. The paper outlines the field for the agricultural engineer and discusses the training required.

Some Considerations Regarding Engineering Education in America, G. F. Swain

This paper discusses the general tendency and development of engineering education in this country. It outlines the elementary curricula of the early engineering schools, the graduates of which built our railroad systems and many of our great municipal works. It considers the difficulties of the more complex requirements and methods of today and suggests they may best be met by cutting off from the top of our present too elaborate and too widely expanded curricula, and in offering the bachelor's degree for a more general course in engineering science and the humanities, in which fundamental principles rather than practical applications are emphasized.

Technical Education for the Professions of Applied Science, Ira N. Hollis

This paper relates to the professional side of applied science and discusses the methods in vogue in this country for training young men for the technical professions. It gives a schedule of studies in American technical schools, comparing the courses in three representative institutions; mechanical engineering schools are selected on account of the workshop courses. It concludes with a discussion of the theories of education as relating to the success or failure of a technical school, and a consideration of these theories applied to the modern American technical college with its mixture of undergraduate and professional studies.

Developments and Progress in "Scientific Management" During Recent Years, E. P. Lesley

Motion Study and Time Study Instruments of Precision, F. B. Gilbreth and L. M. Gilbreth

This paper is for the purpose of disseminating knowledge

of the methods and devices of waste elimination, particularly as to the devices used for making the measurements that enable waste to be eliminated. It outlines and illustrates methods of making time studies or processes of analyzing an operation into its elementary operations and observing the time required to perform them; and motion studies having to do with the selection, invention and substitution of the motions and their variables that are to be measured.

### HEATING AND VENTILATION

Heating and Ventilation, Introductory Paper, R. C. Carpenter

Vacuum, Vacuo-Vapor and Atmospheric Heating Systems, J. D. Hoffman

An analysis of the great changes in the methods of steam heating in the past twenty-five years shows that steam pressures in radiators and coils have dropped from 50 to 60 lb. gage to atmosphere and below. The most recent tendency towards simplicity is an atmospheric, two-pipe, gravity return system, with radiators controlled at inlet and open to atmosphere on end of return.

The paper describes in detail modern mechanical vacuum, vacuo-vapor and atmospheric systems and includes illustrations of the special fittings upon which the efficiency and satisfactory working of these systems are largely dependent.

### THE VOLUMES OF PROCEEDINGS

It is planned to issue the volumes of proceedings between November and January, and members of the Society who did not enroll in the Congress, but who wish to obtain any or all of its publications, should communicate with E. J. Dupuy, Foxcroft Building, San Francisco, Cal. The final arrangement of publication is: Vol. 1, Panama Canal; Vol. 2, Waterways and Irrigation; Vol. 3, Municipal Engineering; Vol. 4, Railway Engineering; Vol. 5, Materials of Engineering Construction; Vol. 6, Mechanical Engineering; Vol. 7, Electrical Engineering and Hydroelectric Power Development; Vol. 8, Mining Engineering; Vol. 9, Metallurgy; Vol. 10, Naval Architecture and Marine Engineering; Vol. 11, Miscellaneous, including Aeronautics, Refrigeration, Agricultural Engineering, Engineering Education, Heating and Ventilation, Scientific Management.

### SOCIAL AND ENTERTAINMENT FEATURES

On the evening of the opening day, a reception was tendered by the Committee on Management to the Honorary President, Vice-Presidents, delegates, members and guests of the Congress. This was held at the Palace Hotel.

A trip was made to Mount Tamalpais by some of the members and guests on Tuesday morning, while on Wednesday afternoon a party was conducted through the Panama-Pacific International Exposition by the local members of the Committee of Management.

In honor of the members and ladies, a lawn party was given in the Faculty Glade, University of California, on the afternoon of September 23, and an automobile ride to points of interest in San Francisco was tendered the visiting ladies on the following afternoon.

The President and Directors of the Panama-Pacific Exposition designated Friday, September 24, as Exposition Engineers' Day. The delegates to the Congress with their ladies were invited to take part in the ceremonies held in the afternoon in the Court of Abundance in honor of the members of the engineering profession who had rendered especially distinguished service to the Exposition. On this occasion bronze plaques were presented to the nine engineers who built the Exposition. Preceding the ceremonies a luncheon was tendered the engineers in the Directors' quarters of the California Building.

On Friday evening a banquet at the Palace Hotel was given to the officers, delegates and members of the Congress and their ladies. Three hundred covers were laid. Prof. Durand acted as toastmaster, and the foreign vice-presidents were represented by Major Jean L. de Pulligny, of the French army. Brig. Gen. W. L. Sibert spoke in place of General Goethals, who had been called away to New York.

By the courtesy of the State Harbor Commission, Jerome Newman, Chief Engineer, a cruise and inspection trip was made along the San Francisco water front on Saturday, September 25, giving members an opportunity of inspecting the harbor and engineering works along the front.

### THE RETURN EAST

For the purpose of showing members of the Congress the engineering works along the line of the Canadian Pacific Railway and the wonderful scenery through the Canadian Rockies, a special train leaving San Francisco on September 25 was run over the lines of the Southern Pacific and Canadian Pacific Railways to Chicago. This train took the members of the party through Portland to Seattle, where a Canadian Pacific Ry. steamer carried them to Vancouver. Here they were entertained royally by the British Columbia Electric Railway Company, Limited, and inspected the company's Coquitlam-Buntzen Hydro-Electric Development which provides electric energy for the city of Vancouver and other cities in lower British Columbia. Continuing through Ruskin, North Bend, Glacier, Lake Louise and Banff, the party arrived at Calgary on Monday, October 4. They were here the guests of the city, were entertained at luncheon at which the Mayor gave an address of welcome, and were shown by the City Engineer the new bridges and the headgates of the Canadian Pacific irrigation system. The big dam at Bassano was the last engineering objective, and the party passed from there through Moose Jaw and Minneapolis, arriving in Chicago on Thursday, October 7.

Left to right—L. F. Leurey, assistant electrical and mechanical engineer of the Exposition; H. D. Dewell, chief structural engineer; Shirley Baker, assistant director of works; H. D. H. Connick, director of works; C. S. Scott; Wm. H. Crocker, chairman of committee on buildings and grounds; Theodore Hardee; Charles C. Moore, president of the Exposition; John A. Britton, vice-president; Carl S. Hehman; Dr. F. J. V. Skiff, director in chief; Dr. John A. Brashear; Prof. C. D. Marx; J. J. Cartt; C. C. Vogelsang, commissioner; F. L. Hutchinson; Calvin W. Rice; Lieut.-Commander C. B. Woodward, U S N.; Charles Warren Hunt; Howard H. Holmes, consulting engineer of the Exposition. chief of construction; W. O. Waters, superintendent of building construction; Guy L. Bayley, chief mechanical and electrical engineer; A. H. Markwart,

ENGINEERS' DAY AT THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION, SEPTEMBER 24, 1915

## ENGINEERS' DAY AT THE EXPOSITION

Friday, September 24, was Engineer's Day at the Panama-Pacific International Exposition. Ceremonies were held in the Court of Abundance, and the purpose of the gathering was well expressed in the remarks of Wm. H. Crocker, Chairman of the Building and Grounds Committee, who spoke as follows:

We are assembled here to-day, in this beautiful place, for the purpose of honoring nine of the engineers who worked faithfully in the construction of this Exposition. The Exposition officials wish to pay them special recognition and have chosen the time of the convening of the Engineers' Congress in order to signal these nine engineers who worked for the Exposition, in a more permanent manner than otherwise would be adopted. The work which these engineers did will never be forgotten. They had a great responsibility. It was due to their careful work that we were able to adjust our finances, adjust the work that was to be done, and so to handle the construction of the work as to make it possible under their direction. They did their work faithfully and well. They did their work within the appropriation and they accomplished it on time. I wish to mention emphatically the names of those who did this wonderful work. They are Harris D. H. Connick, Director of Works; A. H. Markwart, Assistant Director of Works; Guy L. Bayley, Chief Mechanical and Electrical Engineer; E. E. Carpenter, Chief Civil Engineer; Shirley Baker, Construction Engineer; H. D. Dewell, Chief Structural Engineer; William Waters, Superintendent of Construction; W. M. Johnson, Engineer of Fire Protection; L. F. Leurey, Assistant Chief Mechanical and Electrical Engineer. I cannot emphasize too greatly the importance of the services of these gentlemen, and in order to show them the gratitude the Exposition officials feel toward them jointly and severally, President Charles C. Moore will present to each one of them a token of this occasion.

President Moore, referring to the occasion as the "recognition of the engineering profession," and expressing the sentiments of the Exposition in well chosen words, thereupon presented each of the engineers named with a beautiful bronze plaque of Florentine design and inscribed with the legend "This is in Recognition of Services as One of the Engineers of the Panama-Pacific International Exposition, by its Board of Directors, on Exposition Engineers' Day, September 24, 1915." President Moore concluded with the hope that in the records of the engineering societies represented, mention would be made of these men who had honored the Exposition by their enthusiastic, conscientious and most efficient service.

## PRESENTATION AT THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION, OF COMMEMORATIVE MEDAL TO DR. JOHN A. BRASHEAR, PRESIDENT OF THE SOCIETY

The Panama-Pacific International Exposition presented a commemorative medal to Dr. John A. Brashear, as Pennsylvania's most notable citizen, at a ceremonial held in the Court of Abundance, on Wednesday, September 22, which day had been designated by the President of the Exposition, Charles C. Moore, as Brashear Day.

Colonel A. G. Hetherington, Director of Art, Pennsylvania Commission, took the chair and opened the proceedings with these remarks:

We are assembled here for the purpose of honoring a Pennsylvanian, who has been chosen as one of the most beloved, if not the most beloved, of the men of our state. He comes here representing nine millions of people. He has been honored all over the world, but the gewgaws that have been given to him are nothing, because he has, with his great genius, journeyed throughout the Heavens, with its illimitable space. He has within him the heart of a child and the agility of a boy, both physically and mentally. After the presentation of the Commemorative Medal to him by Director Brown you will hear him speak. I will not detain you longer, and thank you for coming here to see our great Pennsylvanian.

Frank S. Brown, Director of the Exposition, in behalf of President Moore, then presented the medal to Doctor Brashear, saying in part:

It is my great pleasure and high privilege to welcome here to-day Pennsylvania's most distinguished citizen, and to pay tribute to the genius of the man who has made not only his own state, but the nation illustrious.

Doctor Brashear is a man whom all the world honors for his accomplishments and above all for that sweet courtesy and kindliness of heart that has endeared him to his friends and to the people of Pennsylvania. When we consider his accomplishments and how he has made possible for those of us who walk on this earth to behold the wonders of the Heavens and to get our inspiration from the planets that are moving through infinite space, surely we can say that to Doctor Brashear may be applied George Eliot's attribute: "The world is but made better for his presence."

We of the Exposition feel that we owe a great debt of gratitude to the engineering profession and to those who have representatives in our councils here—a debt of gratitude we can never repay, because we owe to the engineering profession the rebuilding of the city of San Francisco. It was said, after that great destruction of our city, that it would take years merely to remove the ruins, and you who live here know that in less than three years the city was practically rebuilt. It was said also that it was impossible to build the Panama Canal; in fact, as long ago as 1534 the first Panama Canal Commission appointed by the King of Spain reported to the King that there were not men enough and money enough in any nation in the world to undertake such a great accomplishment!

So we of the Exposition, we of California, and we of this nation want to honor our distinguished citizens, such as Doctor Brashear, feeling that in doing this we are honoring and dignifying the nation itself. We delight in honoring the citizens whom our great commonwealth has selected as its foremost citizen; a man of accomplishment; a man whose sole purpose has been for the benefiting by his life the human race; a man who, without hope of reward or thought of reward, has consecrated his life to the work of uplifting humanity in order that the world might be improved by his presence.

So, in behalf of the Board of Directors of this great Exposition, it is my high privilege to-day to present to Doctor Brashear this bronze medal, typifying as it does the efforts of the human race for more than four centuries in the development of the civilization on the western coast, the efforts of the people of the United States in the completion of the Panama Canal that made possible the linking of all the world together, the energies of the people of San Francisco in the rebuilding of their city, and last, but not least, the building of this magnificent Exposition, which commemorates the achievements of such men as Doctor Brashear and the men of the engineering profession, and so, Doctor, I ask that you accept in behalf of the President and Board of Directors of the Panama-Pacific International Exposition this bronze medal, carrying with it our love, our gratitude, and our appreciation of what you have done for this nation.

Doctor Brashear, in accepting the medal, said he could not conceive why the State of Pennsylvania had gone into the rolling mill and selected a mechanic as its leading citizen, when it had such men as Russell Conwell and John Wanamaker. He continued:

I must, however, say a few words of appreciation of the very kindly address that our good friend has given us in presenting me this medal. His words of praise are far more than I deserve, and far more than I shall be able to acknowledge in my response.

What I best love to say is that, although we may be great engineers, great scientific men or women, but whatever we are, it is our duty to have something else to do, as our good friend Mr. Brown has said, for the uplift and betterment of humanity, and the man or woman who cannot leave a record of having done something of the kind for the world, has lived in vain.

"It may be only a glad good morning
As we pass along the way,
But it will leave a ray of sunshine
Over the live-long day."

I want everybody to go from this place and forget me, but think of the other fellow, whom you can help out of the shadow into the sunlight of this old world. You can all do something. There is a greater accomplishment than that performed by our good friend Brown and his associates in the construction of these magnificent Exposition buildings—a greater work than we engineers and you officials have done in your calling—a greater work than the building of the Panama Canal, which has connected the two oceans. It is ours to break down the conditions that are damning this old world of ours by war, by affliction, by suffering, and by death. You and I can help to do it, every one of us. Let us all, whether we get medals or not, do what we can to make this old round world run smoother on its bearings, by pouring the oil of joy upon them rather than the spirit of heaviness.

Colonel Hetherington said there was no doubt that the Governor of California would be glad to be there, if it were possible, but he had sent a representative. He then introduced Mr. Arthur Arlett.

Mr. Arlett, speaking for the State of California, then addressed the company:

Of course, representing for the moment the State of California, any man with the heart and spirit and vision of this, our honor guest, is counted as one with us; for if there is one thing that we have been trying to establish in this commonwealth in these later years it is this—that the thing of supreme value in all the world is human personality and that that which transcends all other things, talent, finance, commercial greatness, is the human spirit. But with such a man as this, we say as men in California we find in you a fellow worker and a wondrous leader in our great task. To say a word or two, which might be formal, but which cannot really be so in this presence, I wish to say on behalf of our Governor, and as far as I may on behalf of the people of the State, that to this man who so thoroughly typifies that old and wonderful truth that "A child shall lead them" and has demonstrated to us that the surest sign of greatness is simplicity—to this man then we desire to render what homage we may. He feels a sentiment too great for words; he finds, I am sure, that our hearts' desire breaks through and escapes as with true fellowship, beyond any phrase, and beyond any word that human lips can utter.


1 James Hartness, Past-President, Am.Soc.M.E.
2 Worcester R. Warner, Past-President, Am.Soc.M.E.
3 William Gerry Morgan, M.D., Washington, D. C.
4 Ambrose Swasey, Past-President, Am.Soc.M.E.
5 John A. Brashear, President, Am.Soc.M.E.
6 Charles Burckhalter, Director, Chabot Observatory, Oakland, Cal.

Group of Notable Men at the International Engineering Congress

R. L. Countryman, a former citizen of Pennsylvania but resident in California, then spoke:

Pennsylvania has sent from its great borders men and women to preach patriotism and brotherly love, the brotherly love that is so highly typified by the great city of Philadelphia. We people of Pennsylvania, who have left that state for various reasons, retain our admiration and respect for it. We may love California, we may love the Pacific Coast, but still we may also love Pennsylvania.

Doctor Brashear has many accomplishments. His connection with the scientific world has been such that he has been elected into almost all of the renowned societies in the world as an honorary member or as an active member. He is a practical man; in other words, he calls himself a "greasy mechanic." He is a Doctor of Science. It seems also that he has literary accomplishments. He is a scientist—that has been recognized by all the scientific societies in the world. In addition to that, the one thing that most appeals to me in the Doctor is his ability as a maker of astronomical instruments. They say he can make the finest instruments of any man on the face of the earth; and any man who can bring to us the stellar system, so that we may understand the why and wherefore of life, is certainly entitled to be honored by any people.

I remember Professor Bernard, who was formerly at Lick Observatory, taking me to the observatory on the hill when he was in San Francisco, and fixing a clock and glass so that at a quarter of an instant after eight o'clock I would see a certain star. I watched the clock and the star appeared on time. There was no question of delay, there was no question of any lack of ability to reach conclusions. Now, why is this system so perfect? That is the thing that the great astronomers, the men of science, are trying to determine for us to-day and to my mind the highest accomplishment, the greatest ability, is shown in the capacity of the various men who are studying and enabling us to study the solar system to ascertain the effect and cause of it.

We believe that the scientist should be encouraged, that the man who can tell us the mysteries of this system, star for star, and planet for planet, is the man whom we should want to revere; and so to-day, as Pennsylvanians, we are proud to say that we honor the great son of that state who is here today, representative of our great Keystone State. We feel his thoughtful way is leading men on upward to better things, and that the great state of Pennsylvania has reason to be proud that it can name as its most useful citizen, as its most distinguished citizen, the honored guest of this occasion.

# THE APPROACHING ANNUAL MEETING

All the Annual Meeting papers, with the exception of three or four in the hands of committees, are being printed in pamphlet form for advance distribution. Copies of any or all papers will be sent to any member in advance of the meeting upon request. The prospects are that pamphlet papers will be available early and that members who are intending to contribute written discussions will have ample time to prepare them.

The program of the meeting is now completed except in one or two minor particulars and is announced below. This early announcement will enable members living at distant points and who intend to come to the meeting to make their arrangements in advance.

The social features of the meeting will be the reception and the dinner and dance for members and their ladies and guests, and the smoker for members.

One business meeting and seven professional sessions will be held and on one afternoon, excursions have been arranged to points of exceptional interest.

This is the seventieth general meeting of the Society and the thirty-sixth annual convention. It is hoped that all members will find it possible to attend and take part in the deliberations, and so contribute to the success of the meeting. The attendance at annual meetings has been increasing steadily, and last year the attendance was a record one.

## PROGRAM

*Tuesday Evening, December 7*

Opening Session: Address by Dr. John A. Brashear, President of the Society.

Reception by the Society to the President, President-elect, ladies, members and guests.

*Wednesday Morning, December 8*

### Business Meeting

Reports of the Council and Standing Committees. Constitutional Amendments. Announcement of Report of Power Test Committee. New Business.

Immediately following the business meeting, the Society will honor the memory of the late Dr. Frederick W. Taylor, Past-President. The proceedings will consist of a report by a special committee appointed by the President to represent the Society at the Taylor Memorial Meeting held in Philadelphia on October 22 under the auspices of the Society to Promote the Science of Management.

### Professional Session

*Papers to be presented by title only*

Gas Producers with By-Product Recovery, Arthur H. Lymn

The Application of Engineering Methods to the Problems of the Executive, Director and Trustee, Hollis Godfrey, Mem. Am. Soc. M. E.

Modern Electric Elevator and Elevator Problems, David Lindquist

These three foregoing papers contributed by the New York local committee

Turbines vs. Engines in Units of Small Capacities, J. S. Barstow

Contributed by the Philadelphia local committee

The Connors Creek Plant of the Detroit Edison Company, C. F. Hirshfeld, Jun. Am. Soc. M. E.

Contributed by the Buffalo local committee

Proportioning Chimneys on a Gas Basis, A. L. Menzin, Assoc. Mem. Am. Soc. M. E.

The foregoing papers which are to be presented by title will be distributed at the meeting in pamphlet form, and written discussion upon them solicited for publication in The Journal. There will be no opportunity for oral discussion of these papers.

### STEAM POWER

*Papers to be presented by abstract*

Design of Fire Tube Boilers and Steam Drums, F. W. Dean, Mem. Am. Soc. M. E.

Higher Steam Pressures, Robert Cramer, Mem. Am. Soc. M. E.

A Novel Method of Handling Boilers to Prevent Corrosion and Scale, Allen H. Babcock

This paper in preliminary form was presented before the San Francisco local section, December, 1914

*Wednesday Afternoon*

### Simultaneous Sessions

### RAILROAD

*Papers contributed by the Sub-Committee on Railroads*

Operation of Parallel and Radial Axles of a Locomotive by a Single Set of Cylinders, Anatole Mallet, Hon. Mem. Am. Soc. M. E.

Four-Wheel Trucks for Passenger Cars, Roy V. Wright, Mem. Am. Soc. M. E.

Other papers to be announced

### TEXTILE

*Papers contributed by the Sub-Committee on Textiles*

Heating by Forced Circulation of Hot Water in Textile Mills, Albert G. Duncan, Mem. Am. Soc. M. E.

Other papers to be announced

### MACHINE SHOP

*Papers contributed by the Sub-Committee on Machine Shop Practice*

Electric Operation and Automatic Electric Control for Machine Tools, L. C. Brooks, Jun. Am. Soc. M. E.

Report on Code for Abrasive Wheels

Other papers to be announced

*Wednesday Evening*

### SMOKER

A departure will be made from the usual Wednesday evening lecture, by holding a Smoker in the rooms of the Society, to which all members are invited. This will be a get-together, get-acquainted meeting, in charge of the New York local committee, to which every member is invited for a social evening and a good time.

*Thursday Morning, December 9*

### Simultaneous Sessions

### POWER PLANT

The Heat Insulating Properties of Commercial Steam Pipe Covering, L. B. McMillan, Jun. Am. Soc. M. E.

Performance and Design of High Vacuum Surface Condensers, Geo. H. Gibson, Mem. Am. Soc. M. E., and Paul A. Bancel, Jun. Am. Soc. M. E.

CIRCULATION IN HORIZONTAL WATER TUBE BOILERS, Paul A. Bancel, Jun. Am. Soc. M. E.

UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS, Mark A. Replogle, Mem. Am. Soc. M. E.

MISCELLANEOUS

THE FLOW OF AIR THROUGH THIN-PLATE ORIFICES, Ernest O. Hickstein, Jun. Am. Soc. M. E.

This paper is the Junior Prize paper for 1915, and bears the further distinction of being the first paper to receive a prize from The American Society of Mechanical Engineers. A fund for Junior and Student prizes was recently established by a member of the Society.

ELASTICITY AND STRENGTH OF STONEWARE AND PORCELAIN, James E. Boyd

Contributed by the Research Committee

FOUNDATIONS, Charles T. Main, Mem. Am. Soc. M. E.

Contributed by the Sub-Committee on Industrial Building

OIL ENGINE VAPORIZER PROPORTIONS, Louis Illmer, Mem. Am. Soc. M. E.

*Thursday Afternoon*

This afternoon is left free for excursions. Instead of providing for a large number of excursions, as in previous years, the Local Committee has arranged for a few of exceptional interest which it is expected large groups of members and guests will attend.

*Thursday Evening*

Annual Reunion, Dinner and Dance at Hotel Astor.

*Friday Morning, December 10*

INDUSTRIAL SAFETY

Papers are in preparation, of which definite announcement will be made later, on the following subjects:

Safety Standards in Industrial Establishments

Modern Movement for Safety from Standpoint of Manufacturer

Methods of Reducing Accidents Through Coöperative Movements with Workmen

Compulsory Compensation for Accidents by Law

This session is under the direction of the Sub-Committee of Protection to Industrial Workers.

## ABSTRACTS OF PAPERS

Abstracts of the papers to be presented at the Annual Meeting will appear in this and the next numbers of The Journal. These abstracts, while brief, will serve to furnish members with an adequate idea of the contents of the papers, and will be of assistance to any member in selecting those papers of particular interest to him and to the discussion of which he might desire to contribute.

### GAS PRODUCERS WITH BY-PRODUCT RECOVERY

By ARTHUR H. LYMN

The object of this paper is to present an historical resumé of the development of the by-product producer gas industry in Europe.

As far back as 1883, Young and Bielby in England claimed to recover in the form of ammonia from 60 to 70 per cent of the total nitrogen in the fuel, and although their retort was heated from the outside instead of the air and steam blast being superheated this ammonia recovery is not far short of what we realize to-day.

Two years later Dr. Mond first put into commercial practice his process of gasifiying fuel by means of steam and air and simultaneously recovering the ammonia. Up to 1897 Dr. Mond was constantly endeavoring to improve his process, but after that time he appeared to be satisfied with its design.

E. J. Duff, whose interests were afterwards amalgamated with Dr. Mond's into the Power-Gas Corporation, brought out a plant which differed from the Mond plant only in the design of the superheater. Several large Duff plants were constructed.

The next improvements were claimed by Crossley Bros., who introduced a plant in which the washing and cooling of the gases, as well as the condensing of the water vapor and the absorption of the ammonia took place in one and the same appparatus.

The author replaced the irksome towers of these early plants by a system of vertical washers. He substituted steel for lead in the parts of the ammonia absorbing apparatus, and made improvements in the removal of dust by adopting a cyclonic dust separator of somewhat special design.

In the gas producer itself, mechanical agitation in the fuel and ash zones and mechanical ash removal were introduced. Modifications of this system applied to ammonia recovery plants resulted in a vastly increased volume of air and steam, a deeper fuel bed, superheating of the blast, increased blast pressure and consequently deeper water lute.

Ammonia recovery plants have been applied for power as well as for heating purposes. Power gas and by-products are now regularly produced from peat containing up to 60 per cent water.

### APPLICATION OF ENGINEERING METHODS TO THE PROBLEMS OF THE EXECUTIVE, DIRECTOR AND TRUSTEE

By DR. HOLLIS GODFREY, MEM. AM. SOC. M. E.

This paper is an endeavor to determine the methods by which the service of a consulting engineer may be made of greatest value to the executive of a corporation, or to a board of directors or trustees, during the interregnum in an executive office. After an experience of several years, the author has found the following method of value.

(*a*) The defining, on the basis of facts shown by engineering study, of the policies of a business.

(*b*) The expression in simple usable form of the definitions obtained.

(*c*) Construction on the basis of studies made.

Money saving and money making, time saving and improvement of service are all intimately connected with proper definition and expression of facts about a business.

The consulting engineer who is serving a corporation should present to the executive a general preliminary coöperative study of the field to determine what lines are most worthy of study, a coöperative determination of what facts should be known about these lines, a careful collection and intensive study of the facts existing in the lines chosen, the translation of the facts collected in the light of their relation to the other departments of the business, the expression of the facts studied and a method for the constructive use of the facts obtained.

The coöperative engineering adviser to an executive must be able to distinguish clearly between records which are vital to the future policies of a business and those which are merely historical; the past in industry as a determinant for policies is of value only as it is vitally concerned with the future. He must omit many engineering refinements, to avoid doing work that costs more than it is worth. He must check his work with the practical needs and limitations of the business. He must keep abreast of the "best of the art." He must have a wide acquaintance with professional men and must be able to bring to bear upon the problem before him the best that science and industry have yet produced.

## MODERN ELECTRIC ELEVATOR AND ELEVATOR PROBLEMS

By David Lindquist

This paper is an interesting treatise on the problem of the modern electric elevator in its bearing upon the construction of tall buildings in the large cities. It is a clear analysis of building elevator practice in general and points out the steps in the development of electric elevator practice, wherein the traction type of electric elevator has come to replace all of the earlier highly developed hydraulic types. The possibility of locating the traction elevator machine at the top of the hatchway has, it is showu, been a powerful factor in its development.

The problems that have attended the development of the traction electric type are outlined, including those of roping, counterweight and rope compensation, construction of the motor, armature shaft bearings, power consumption, and safety devices. The electrical achievement in the design of a motor capable of operating efficiently at 60 r.p.m. and less, is, of course, responsible for this radical design of elevator machine, but incidentally, this form of design affords unusual opportunities for interesting and very efficient methods of braking and control.

In the consideration of the power consumption of this type, careful attention is given to the character of the service handled in numerous specific cases. The requirements for elevator service in tall buildings in the large cities are, in fact, so exacting that only by the most effective control, as is afforded by a traction type of machine, can satisfactory service be given; the traction design is shown to lend itself readidly to quick starting and stopping, and rapid rates of travel between floors.

The author concludes with detailed reference to a new form of safety device which has been worked out in connection with the application of elevators of this type to the high-speed, high-rise service. The requirements for safety devices in this class of service are pointed out, and the interesting constructional details, by means of which the various requirements are fulfilled, are described.

## TURBINES VS ENGINES IN UNITS OF SMALL CAPACITIES

By J. S. Barstow

The author limits the term "units of small capacities" to steam turbines and engines of less than 500 h.p. capacity, and an effort is made to point out the fields within this range where the small turbine is of conceded superiority, and likewise the other fields wherein the engine must hold sway. Within the past few years, the practicability of the small turbine has been definitely established, and with it results are shown that in many cases exceed those obtainable with the engine.

In comparing the two types of prime movers, the author considers them with regard to: *a.* Speed conditions and limitations; *b.* Steam pressure and temperature conditions; *c.* Power capacity of turbines; *d.* Relative space requirements; *e.* Use or application of the exhaust steam; *f.* Available cooling water supply; *g.* Operating conditions; *h.* Relative cost of complete installations.

The paper concludes with a classification under the headings: direct connected units, condensing; direct connected units, non-condensing; and geared units, indicating the classes of service under which each of the two types is more applicable.

## THE CONNORS CREEK PLANT OF THE DETROIT EDISON COMPANY

By C. F. Hirshfeld, mem. am. soc. m. e.

This paper is a discussion of the power plant problem of the Detroit Edison Company in the City of Detroit, whose phenomenal growth as a result of an unusual industrial development has brought interesting questions to the company. It became evident in 1912 that greatly increased power producing capacity would soon be required, and after an extended consideration of the requirements of the distribution system in its relation to the present large plants at Delray, it was decided to construct a large new additional power plant at the opposite end of the city. In connection with this decision, interesting statistics are presented relative to the growth of population of the city, the increase in the annual power output, and of the load factor.

The reasons that decided the interesting layout at the Connors Creek site are discussed, and the opportunities for introduction of interesting features of design are outlined. The arrangement for coal and ash handling, and the construction for future development were effective in bringing about a most unusual design of plant and equipment.

Special mention is made of the large boiler units and their layout in relation to the turbine units operated from them; two of these boiler units are installed to supply each of the 25,000 k. v. a. turbo-generator units. The details of the steam piping and other auxiliaries are described, with special reference to the jet condenser equipment used in connection with steam driven auxiliaries for feed water heating. The paper concludes with a description of the electrical system with its switching and control equipment.

## PROPORTIONING CHIMNEYS ON A GAS BASIS

By A. L. Menzin, assoc-mem. am. soc. m. e.

This paper reviews the subject of calculating the proportions of chimneys, taking into account the increasing tendency to operate boilers at higher overloads, the attention being given to baffling as a factor in improving boiler performance and the efforts to improve the efficiency of combustion, resulting in a reduction of the volume of gases to be removed.

It considers mathematical expressions for deducing the effective draft and height of a chimney; for determining the maximum draft produced by a chimney; for finding the draft

required to produce a change of velocity of the chimney gases; for calculating the loss of draft due to sudden enlargement of gas passage; for expressing the friction loss in breeching and chimney, and for arriving at the draft required at the boiler damper. It describes the method of converting boiler horse power into gas volume to enable the utilization of the principles discussed, and illustrates the application of the formulae and data for calculating chimneys on a gas basis by working out a practical problem in detail.

## DESIGN OF FIRE TUBE BOILERS AND STEAM DRUMS

By F. W. Dean, mem. am. soc. m. e.

This paper considers what makes steam boilers dangerous and how certain parts should be designed in order to make them safe. It is intended as an extension of the Society's work, through its Boiler Code Committee, in devising rules for the construction and care of steam boilers.

The great and usual cause of weakness in boilers is the bending of some part first one way and then the other with the appplication and removal of pressure, causing cracks. This part is usually the longitudinal joint, and the lap form of this joint has been a prolific cause of explosions. Butt joints, properly designed, have practically eliminated this cause.

A detail of boiler making which needs more careful attention is that of bending plates.

Boiler head braces should be supported so as to prevent movement in any direction, instead of merely supporting the weight.

In riveting, the best practice is undoubtedly to drill all holes from the solid.

A conical course in the outside firebox of a vertical boiler is preferable to a reversed flange. The latter bends backward and forward under pressure, and is liable to crack.

Dished heads "breathe" with changes of pressure, causing them finally to crack round the flange. Such heads should be made thinner and braced like flat heads.

Tight brickwork is desirable to prevent the leak of air, with its harmful effect on draft and economy.

Horizontal return tubular boilers, no matter what their length or size, should be supported at no more than four points. The three-point principle of supporting boilers is the best, and this effect can be obtained and yet have the boiler held up at four points by connecting two points to an equalizing lever working on a pin passing through overhead supporting beams.

## HIGHER STEAM PRESSURES

By Robert Cramer, mem. am. soc. m. e.

Theoretical considerations, based on the laws of thermodynamics, point out that the economy of steam engines and turbines could be further improved by increasing steam pressures over those now commonly in use. The probable gains for different conditions are given graphically and in tabular form.

Practical difficulties arising from the problems of design and operation of engines, turbines, boilers, and fittings are broadly discussed and the conclusion is reached that higher steam pressures should prove practical and profitable.

## OPERATION OF PARALLEL AND RADIAL AXLES OF A LOCOMOTIVE BY A SINGLE SET OF CYLINDERS

By Anatole Mallet, hon. mem. am. soc. m. e.

The author undertakes in the paper an analysis of the many attempts that have been made for the transmission of power to convergent axles of locomotives from a single set of steam cylinders. In the discussion, the mechanisms on records for this purpose are divided into two classes: *first,* those involving elements having rotary motion, and *second,* those involving elements having reciprocating motion. In the first class it develops that there are several examples on record that utilized gear transmissions of interesting form, while another group made use of endless chains; a third group has driving mechanism consisting of universal joint connections between trucks, a form of construction most applied in the United States.

Of the class utilizing reciprocating motion, many interesting examples are quoted. These are divided in the following groups: Those operating connecting rods located in the longitudinal axis of the engine; those coupling by oscillating levers or equalizers; those using free axles; those using external connecting rods of which the length varies with the convergence of the axle.

## FOUR-WHEEL TRUCKS FOR PASSENGER CARS

By Roy V. Wright, mem. am. soc. m. e.

There are four important factors which demand attention in the designing of trucks for railway passenger cars. These are, in the order of their importance, safety, smooth riding, minimum weight and low cost of maintenance. The Pennsylvania Railroad uses four-wheel trucks for carrying much heavier passenger cars than do most of the other railroads in this country. The paper deals with the development of the modern steel four-wheel truck for passenger service on that system, giving particular attention to the degree to which it meets the above requirements.

## ELECTRIC OPERATION AND AUTOMATIC ELECTRIC CONTROL FOR MACHINE TOOLS

By L. C. Brooks, jun. am. soc. m. e.

In the early application of electric motors to machine tools, the motors were started by hand starters. While there are a number of cases in which these starters are still more applicable, we have reached the time when automatic starters, remote controlled, are the most suitable.

Some of the advantages of automatic control are: The operating switch is easily attached to the machine and the main panel may be located at a distant point. The starting time of the machines is automatically regulated to suit the load conditions on the motor. Accurate stopping points are obtained by "dynamic braking."

All panels should be provided with fool-proof enclosing cases, meeting applicable safety-first requirements, for protecting the appliances from injury and the operator against accidental contact. All automatic starters and control apparatus should be provided with protection from low voltage on the line, also from excessive overload.

The three general types of automatic starters are *time element, counter E.M.F.* and *current limit.* Starters for small motors consist of line contactor, overload relay, field rheostat and connecting board. For larger motors, where one step of resistance is necessary, they include line switch and fuses, contactor, C. E. M. F. accelerating contactor and connection board. For still larger motors the latter is modified to accommodate the additional accelerating contactors.

At the present time, the problem of purely automatic control for general lathes has not been entirely solved, although lathes for a special class of work have been controlled with safety and efficiency. Automatic control equipment has been applied to boring mills, planers, and slotters.

Not the least important factor for a successfully operating electrically controlled machine is the motor. For small printing presses, ventilating fans, small machine tools, woodworking machines, etc., the shunt motor is applicable and for adjustable speed work it is suitable for planers, boring mills, heavy lathes, etc. The series motor should always have a certain friction load and is thus applicable to centrifugal pumps, cranes and hoists.

## SAFETY CODE FOR THE USE AND CARE OF ABRASIVE WHEELS

During the year 1914 a committee of the National Machine Tool Builders' Association studied the question of a Safety Code for the Use and Care of Abrasive Wheels. This report was presented before the Worcester meeting of this association, following which representatives of abrasive wheel manufacturers conferred on the matter and made certain modifications, based in part on a tentative report on the subject by a special committee appointed by the State of Pennsylvania. The Sub-Committee on Machine Shop Practice of the American Society of Mechanical Engineers has considered this revised report and made further suggestions and now submits the code with these features added for discussion at the Machine Shop Session of the Annual Meeting.

## THE HEAT INSULATING PROPERTIES OF COMMERCIAL STEAM PIPE COVERINGS

By L. B. McMillan, jun. am. soc. m. e.

While an enormous amount of effort has been expended in attempts to determine accurately the savings effected by the use of non-conducting coverings on steam pipes, little information is on hand regarding the efficiencies of pipe coverings in commercial use at the present time. Most of the early results of tests apply at only one temperature or two at most, and for one or two thicknesses; they are not applicable to modern conditions involving high superheat and thicker coverings.

The paper describes an investigation of the effect on heat losses of varying the temperature difference between pipe surface and air, between the limits of 0 and 500 deg. fahr. Different thicknesses of material from 0 to 3 in. were tested and the laws confirmed. The drops in temperature from steam in a pipe to the inner and outer surfaces of the pipe wall under various conditions were accurately determined.

A new fact brought out was that the loss from any covered pipe is a function of the temperature difference between the surface of the covering and the surrounding air, and this function is the same for all coverings having the same character of surface regardless of what the other properties of the covering may be, since the effects of these appear in the temperature difference. The value of this was determined for canvas covered surfaces, and a complete explanation of its significance is given.

While a careful study of conditions is necessary before a certain type of covering can be recommended for a certain type of work, the author hopes the data given in the paper will be of use to engineers in deciding upon covering material and in calculating heat losses in installations already in use.

## CIRCULATION IN HORIZONTAL WATER TUBE BOILERS

By Paul A. Bancel, jun. am. soc. m. e.

Flowing within a boiler under steam are two fluids, steam and water, and these have different velocities, the steam being said to "slip" through the water.

By considering the flow in a simple circuit, and citing experiments with the air lift, an example of such a circuit, the conditions favorable and otherwise to slip are revealed. These experiments indicate that slip and friction change the relation of volume to velocity to nearly the square root law.

In an actual water tube boiler, with the circuit more complex, it is shown that with the bottom tubes discharging a light weight mixture and with slip and eddies due to the large area of the header and resistance due to the restricted area and abrupt turn at the entrance to the drum, there is a choking of circulation, particularly in the bottom tubes where it is most needed.

Constructions with circulation flues in the front header as means of improving circulation are shown.

Photographs illustrating the circulation, both front and rear, in the header of a model boiler with glass cover plates and with different types of headers and relative positions of boiler, fire and gas passages, show strikingly the conditions obtaining at loads up to 500 per cent.

## UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS

By Mark A. Replogle, mem. am. soc. m. e.

The hydraulic power plant recently constructed at the Henry Ford Farms contains two turbines designed to develop 85 h.p. each under 8 ft. head at 110 r.p.m., with electric generators. Current is supplied for light, heat and power for the residence, the village pumping station, and for the miscellaneous requirements of the farms.

There were unusual flowage conditions due in part to high water at certain periods and in part to back water from the Great Lakes. These conditions were met, and a uniform delivery of power secured, through the adoption of unusual features in the installation of the turbines. These features in the main consist of so-called turbine discharge accelerators built into the tailrace of each turbine, whereby an added head-effect is produced and the flow through the turbine increased. The accelerator consists of a form of draft tube into which the turbine discharges and into which, also, water from the upper level is discharged through a feeder terminating in an annular ring surrounding the outlet of the

discharge tube from the turbine. The water from the feeder increases the flow—accentuates the flow through the draft tube. Experiments conducted at this plant indicate: (1) That the turbines can be speeded for full head at low water conditions; (2) that if water is available, the power capacity of the turbine can be practically doubled at the same head; (2) that if water is available the unit can develop its normal rated power at one-half head; (4) that considerable power can be furnished at normal speed when the working head is less than 25 per cent of the normal head. All of this may be accomplished at good efficiency.

## THE FLOW OF AIR THROUGH THIN-PLATE ORIFICES

By Ernest O. Hickstein, jun. am. soc. m. e.

This paper describes in some detail the methods used by a large pipe-line company in the Mid-Continental field in the calibrating of its orifice meter discs.

An orifice meter consists of a calibrated disc in a pipe-line, with pressure line connections running to two indicating or recording gages; one gage is for measuring the static pressure of the flowing gas and the second the differential drop of pressure across the orifice disc.

The paper deduces the following general formula for the flow of air through an orifice disc:

$$Q_o = C_g\sqrt{hP_1}$$

where

$Q_o$ = volume at standard temperature and pressure

$C_g$ = so-called "gas constant," found experimentally

$h$ = differential in in. of water

$P_1$ = pressure at inlet of orifice

It then describes in detail tests made on orifice meters at Joplin, Mo., to determine the velocity coefficients of 8 and 10-in. orifice meters. The discs were calibrated against the displacement of air from an old artificial gas holder, with lower lift capacity of 110,000 cu. ft. Preliminary tests were run to determine leakage from the holder and changes of volume in holder with temperature variation.

About 160 tests were then run on 8 and 10-in. meters; a summary of the results is given in the paper.

Nearly fifty orifice meters have been installed and are now in operation, their deliveries of high pressure gas being calculated from the air constants found in the Joplin tests. It is confidently expected that, with some little further study and experimenting, the orifice meter will take its place among the most reliable methods of measuring natural gas in large quantities.

## ELASTICITY AND STRENGTH OF STONEWARE AND PORCELAIN

By James E. Boyd

This investigation was undertaken at the suggestion of Ralph D. Mershon, Mem. Am. Soc. M. E., who expressed the belief that exact knowledge of the form of the stress-strain diagrams of clay products in tension and compression would make possible the design of insulators of greater mechanical strength and more definite factor of safety.

The pieces tested were porcelain pieces from the General Electric Co., stoneware pieces from the Keasbey Stoneware Works and also some porcelain pieces made in the Department of Ceramics of the Ohio State University.

All measurements of deformation were made by means of a lever extenso-meter, a Brown and Sharpe micrometer being used to measure the movement of the longer arm.

A form of grip was developed which eliminates the eccentricity of loading of the best pieces due to lack of perfect symmetry in the heads of the pieces. With all grips, however, it was found that the test pieces broke at the head, so the form of the pieces was modified.

The results of the tests indicate that the modulus of elasticity of stoneware and porcelain is practically the same in tension as in compression. The modulus of elasticity of porcelain is about 10,000,000 while that of stoneware ranges from 6,000,000 to 9,000,000, depending on the material. The compressive strength of porcelain and high stoneware in a column 16 in. long and 1 in. in diameter is about 20,000 lb. per sq. in. The stress-strain diagram is practically straight up to 7000 lb. per sq. in. The tensile strength of porcelain is above 3000 lb. per sq. in. The tensile strength of stoneware ranges from above 1100 to above 2200 lb. per sq. in.

## FOUNDATIONS

By Chas. T. Main, mem. am. soc. m. e.

It is of great importance to support all structures on a stratum of soil below silt or peat. If the structure is to be a heavy one, it is necessary to use piles. Buildings which are to contain moving machinery or delicate instruments would naturally require piles with fairly large factors of safety.

Soils are tested as to their suitability for foundations by making wash borings. Test pits furnish an opportunity of observing the character of the soil. If the structure is to be a heavy one, some of the borings should be carried to bed rock and dry samples of the soil taken every few feet.

Work on foundations consists of excavation of earth or rock, including shoring, sheet piling, or coffer dams, and a structure of stone, concrete, brick or timber at the bottom of the excavation, including bearing piles.

Where the depth of good bottom is too great to be reached economically by the foundations, it becomes necessary to use piles, the values of the factor of safety and working or ultimate strength of which are all to be fixed to suit the class of structure to be supported.

The structures most commonly used at the bottom of the excavation are concrete, stone laid in cement mortar or bedded rock, stone laid with outside joints pointed and then grouted full, and stones laid dry.

## OIL ENGINE VAPORIZER PROPORTIONS

By Louis Illmer, mem. am. soc. m. e.

This paper is the synopsis of a research made some time ago to determine the proper proportions of hot bulbs for oil engines of the Hornsby-Akroyd type, and largely extended of late to include high compression oil engine vaporizers.

The vaporizer of low compression oil engines is heated by the gases of combustion and provides a hot surface for the double purpose of evaporating the heavy mineral oils in the fuel-oil and of maintaining the confined mixture charge at a temperature high enough to enable self-ignition to be induced.

The one simple relation suitable for design purposes is that of vaporizer volume to piston displacement. The other design factors depend upon more involved relations and con-

ter about the average temperature attained by the unjacketed cap portion of the vaporizer wall. By analysis, the average full load cap temperature of a Hornsby-Akroyd engine is found to be about 1275 deg. fahr. The total vaporizer volume should be about 0.3 of the piston displacement or about 2/3 the clearance volume.

When a Hornsby-Akroyd engine is running on 1/3 to ½ of the full load oil, the hot products of combustion may be expected to raise the temperature of the entire vaporizer content to 750 deg. fahr. ignition temperature. Below this critical point, the temperature head is reduced to such an extent that the cap no longer keeps the vaporizer content sufficiently preheated to reach the ignition temperature at the end of the compression temperature. The limit of efficiency and m.e.p. of the engine are so restricted as to make it quite cumbersome in sizes of 50 b.h.p. and upward. This limitation may be overcome by injecting the fuel-oil, by means of highly compressed air, near the end of the compression stroke.

High compression oil engines operating at less than 135 lb. per sq. in. compression pressure should have their vaporizer volume made equal to the entire clearance space, while in high compression engines the vaporizer volume may be made proportionally smaller; at about 400 lb. compression the vaporizer may be dispensed with. The moderate preheating requirements of the high compression engine allow self-ignition to be attained without maintaining the vaporizer cap at full red heat; this reduces internal strains in the cap casting.

## COUNCIL NOTES

At the meeting of the Council on October 8, 1915, it was voted to approve the following recommendations with regard to the Society's publications, as made by the Publication Committee:

*Transactions*

(1) That the publication of the annual volume of Transactions be continued.

(2) That it be published in the same size and binding as heretofore.

(3) That it shall contain subject to the approval of the Publication Committee, all of the papers and discussions presented at regular meetings of the Society (not including section meetings), and technical reports of Committees; and shall contain a syllabus of each paper, summarizing the essential facts and conclusions.

(4) That it shall contain all the papers and discussions presented at section meetings which in the opinion of the Publication Committee are of sufficient merit.

*Revises*

(1) That additional revised copies of the papers and discussion be printed and bound in pamphlet form at the earliest practicable date.

A charge will be made for such pamphlets.

*Advance Papers*

(1) That papers for the meetings of the Society be printed in pamphlet form in advance as heretofore, and be sent to members gratis upon request, a notice of these papers with syllabi being printed in The Journal one month before meetings.

*The Journal*

(1) That The Journal be published monthly as heretofore, but with the view of making it a semi-monthly or a weekly as soon as the amount of matter to be handled requires it and funds for that purpose are available.

(2) That the size of The Journal shall for the present remain as it now is.

(3) That The Journal shall contain:

(a) All of the papers and discussions presented at regular meetings of the Society, preferably in substantially complete form, or adequately abstracted, according to the character of the paper, as soon after the meetings as possible.

(b) Papers, or abstracts, with discussion, presented at meetings of Local Sections.

(c) Announcements and reports upon Society affairs and incidents, employment bulletin, library notes, personal notes, etc.

(d) Department for contributed discussions on papers previously published, or new matter.

(e) Members correspondence department, including suggestions on Society affairs.

(f) Review of world's technical press.

(g) Review of technical books, by experts selected by the Committee.

The Committee adopt as a policy that the Editor shall coöperate with the author to present all papers and discussions as concisely as possible, consistent with clearness and completeness. This not only adds to the utility of the paper, but will make possible the publication of more papers in complete form. An abstract should be done by the author. The Editor will coöperate towards securing uniformity.

The paper, "Flow of Air Through Thin Plate Orifices," by Ernest O. Hickstein, Jun. Am. Soc. M. E., was approved for the Junior Prize.

No award of the Student Prize was made this year.

W. L. R. Emmet and Spencer Miller were reported elected as the representatives of the Society on the Naval Consulting Board. The appointment by the President of W. R. Dunn to represent the Society at the inauguration of John Henry MacCracken as President of Lafayette College was reported. Wm. H. Wiley was appointed delegate of the Society to the convention of the Atlantic Deeper Waterways Association.

The Boiler Code Committee was empowered to make rulings where inquiries are made respecting constructions not covered by the Code, and to interpret any parts of the Code, but the action on all rulings made by the Committee was ordered reported to the Council for approval before being issued.

The appointment as a Committee on Sections in Los Angeles of W. W. Smith, *Chairman*, W. A. E. Noble, *Vice-Chairman*, Ford W. Harris, *Secretary*, O. J. Root and Frederick C. Finkle was approved. Leigh Hunt was appointed on the Increase of Membership Committee, in place of H. Struckmann, resigned.

The substitution of a Smoker for the usual Wednesday evening address at the Annual Meeting was authorized.

Calvin W. Rice, *Secretary*.

## REPORT OF THE NOMINATING COMMITTEE

As previously announced in The Journal, the Nominating Committee has reported the following names as candidates for the offices indicated:

*For President:*

D. S. Jacobus, New York

*For Vice-Presidents:*

Wm. B. Jackson, Chicago, Ill.
J. Sellers Bancroft, Philadelphia, Pa.
Julian Kennedy, Pittsburgh, Pa.

*For Managers:*

John H. Barr, New York
John A. Stevens, Lowell, Mass.
H. de B. Parsons, New York

*For Treasurer:*

Wm. H. Wiley, New York

## CONFERENCE OF LOCAL SECTIONS AT THE ANNUAL MEETING

The great success attending the Conference of Local Sections at the Spring Meeting has prompted the Committee on Sections to arrange for such meetings of Section representatives to be one of the regular features at the Annual or Spring Meetings. Many items of considerable importance were developed at the last Spring Meeting and delegates were present from San Francisco, Atlanta, Milwaukee, Chicago, New York, Providence, Philadelphia, Cleveland, Worcester, Birmingham, etc. All Sections were not represented however, and it has been arranged therefore to pay the traveling expenses of an officer of every Section in the United States.

Preferably the delegate should be the Chairman or Secretary, if either of them may find it possible to attend, or the member of the local committee conversant with its activities. By this action it is hoped to have every Section represented by a delegate who can officially and comprehensively present the views and requirements of the members in their locality.

Invitations have been extended to several centers where no Section now exists to authorize some member to participate at the Conference with a view to establishing a Section.

It is hoped by this means to develop thoroughly and put on an efficient basis this very important phase of the Society's activities. Information may be obtained by addressing any member of the Committee on Sections.

Elliott H. Whitlock, *Chairman,* 1506 West 112th St., Cleveland, Ohio
W. F. M. Goss, Univ. of Illinois, Urbana, Ill.
L. C. Marburg, 1790 Broadway, New York, N. Y.
Walter Rautenstrauch, Columbia Univ., New York, N. Y.
D. Robert Yarnall, Chestnut Hill, Philadelphia, Pa.

## STUDENT BRANCH CONFERENCE

Representatives of various Student Branches of the Society held a meeting at the last Annual Meeting and so much benefit was derived by those who attended that it was voted to make the Student Branch Conference one of the regular features of the Annual Meeting.

Invitations have been issued therefore to all Student Branches to appoint delegates to the Conference at the coming Annual Meeting. Some of the colleges are at such a great distance that it will probably be impossible for the Student Branch to send an undergraduate representative. It is hoped that those Branches who cannot send an undergraduate will arrange for a graduate or one of the faculty to represent them.



Medallion Presented by the Panama-Pacific International Exposition to The American Society of Mechanical Engineers, September 16, 1915

## CORRECTION

### LABORATORY FOR LIQUID METERS

In a letter dated September 28, Geo. H. Gibson points out an error in his discussion of the paper on Laboratory for Liquid Flow Meters by W. S. Giele, published in Vol. 36 of Transactions, page 757. In place of the first paragraph of his discussion, the following paragraph should be substituted:

It is ordinarily assumed that the flow over a V-notch weir increases as the 5/2 power of the head, that is according to the formula $F = CH^{5/2}$ This assumption possibly simplifies calculations and in the absence of facilities for testing V-notch weirs under all conditions and heads, manufacturers of flow recorders for use with such weirs have used it in the laying out of the cams of the recorders, by means of which the rise of the float measuring the head on the weir is translated into the motion of the pen recording the flow.

## NEW EDITION OF THE BOILER CODE

A second edition of the Boiler Code which contains a comprehensive index to the volume has been issued. The index is divided into two parts, one a general index to the complete rules and the other containing sectional indexes to the parts referring to New Installations of Power Boilers, New Installations of Heating Boilers, and Existing Installations.

## NAVAL ADVISORY COUNCIL AND NAVAL CONSULTING BOARD

The historic photograph on this page was taken at the first meeting of the Naval Advisory Council and the civilian Naval Consulting Board at Washington on October 6, 1915. This is the first time that civilians, representing the public through the national engineering societies, have been called into convention with officers of the Government to discuss problems of the Navy. The photograph shows the Secretary of the Navy, Hon. Josephus Daniels, seated beside Thomas A. Edison, and the departmental associates of the former in convention with the country's distinguished and leading civilian inventors and engineers.

The members of the Naval Advisory Council are practically all chiefs of departments; they welcomed the formation and organization of the civilian Board, the latter to constitute a non-partisan research body to assist in passing upon inventions and ideas submitted to the Navy.

At the first meeting of the joint Boards, Thomas A. Edison was elected Chairman of the civilian Board; Peter Cooper Hewitt, First Vice-Chairman; William L. Saunders, Second Vice-Chairman; and Thomas Robins, Secretary. The entire civilian Board is being resolved into committees.

Secretary Daniels appointed Rear Admirals Taylor, Strauss and Griffin as a Committee on Inventions in the Navy Department, and this committee is to appoint an officer to receive all suggestions from in-



1. Rear Adm. Robert S. Griffin (n).
2. Benjamin G. Lamme (c).
3. Rear Adm. Victor Blue (n).
4. Rear Adm. David W. Taylor (n).
5. Spencer Miller (c).
6. Frank J. Sprague (c).
7. Henry A. W. Wood (c).
8. Lawrence Addicks (c).
9. Capt. Ridley McLean (n).
10. Howard E. Coffin (c).
11. Rear Adm. Joseph Strauss (n).
12. Thomas Robins (c).
13. Wm. Leroy Emmet (c).
14. L. H. Baekeland (c).
15. W. L. Saunders (c).
16. Maj. Gen. George Barnett (n).
17. Thomas A. Edison (c).
18. Hon. Josephus Daniels (n).
19. W. R. Whitney (c).
20. Peter C. Hewitt (c).
21. Rear Adm. H. R. Stanford (n).
22. Joseph W. Richards (c).
23. Alfred Craven (c).
24. Benjamin B. Thayer (c).
25. Andrew M. Hunt (c).
26. Elmer A. Sperry (c).
27. Arthur G. Webster (c).
28. Hudson Maxim (c).
29. Andrew L. Riker (c).
30. Surg. Gen. Wm. C. Braisted (n).
31. Rear Adm. Wm. S. Benson (n).
32. Robert S. Woodward (c).
33. Mathew B. Sellers (c).
34. Paym. Gen. Samuel McGowan (n).
35. M. R. Hutchinson.

(n) = Naval Advisory Council.
(c) = Civilian Naval Consulting Board.

FIRST MEETING OF NAVAL ADVISORY COUNCIL AND CIVILIAN NAVAL CONSULTING BOARD, WASHINGTON, OCTOBER 6, 1915

ventors. Promising inventions will be forwarded by this committee to each member of the civilian Board, and each is expected to express an opinion respecting the feasibility of the invention or to mark it "no report." The Boards recommended a plan to establish a research laboratory to cost eventually $5,000,000, and the Secretary of the Navy will ask Congress for an appropriation of $1,000,000 to begin work. The essentials of the plan for this laboratory in which it is proposed to submit to actual test all seemingly meritorious naval inventions are as follows:

1. The laboratory to be located on tidewater of sufficient depth to permit a dreadnought to come to the dock; near but not in a large city, so supplies may be easily obtained and where labor is obtainable.
2. The laboratory to be of complete equipment, to enable working models to be made and tested to destruction. There should be: A pattern shop; a brass foundry; a cast iron and cast steel foundry; machine shops for large and small work; sheet metal shop; forge shop for small and large work; marine railway large enough to build experimental submarines of 1,500 tons; woodworking shops; chemical laboratory; physical laboratory; optical grinding department, &c.; motion picture developing and printing department; complete drafting rooms; electrical laboratory and wireless laboratory; mechanical laboratory and testing machines; explosives laboratory, removed from main laboratory.
3. The building to be of modern concrete construction, with metal sills and doors, wire glass windows, ample fire protection, &c.
4. A naval officer of rank to be in charge. Under him naval heads of broad experience in laboratory methods and science in general—practical as well as theoretical men. Under them staffs of civilian experimenters, chemists, physicists, &c. Each subhead to have his corps of assistants, and shop facilities. There is to be at least two, and possibly three shifts of men.
5. Secrecy to be the governing factor.
6. Facilities to exist for enabling the inventor to assist in the development of the idea he has presented, provided he is a practical man.

The next meeting of the Boards will take place on November 4 in New York City.

## MEMORIAL SERVICE TO PAST-PRESIDENT FREDERICK WINSLOW TAYLOR

A remarkable service was held in Philadelphia Friday evening, October 22nd, in Houston Hall of University of Philadelphia, under the auspices of the Society to Promote the Science of Management. The hall was filled to overflowing with many of the leaders in management, representatives of Philadelphia's citizens and the following official participants in the meeting:

The provost of the University, Edgar Fahs Smith; the Mayor of Philadelphia, Rudolph Blankenburg; President of the Society to Promote the Science of Management, Dr. Harlow S. Person; Louis D. Brandeis; Past-President of this Society, James M. Dodge; three former associates of Mr. Taylor, all members of this Society, H. L. Gantt, Carl G. Barth and Sanford E. Thompson; and Colonel Vignal, military attaché at the French Embassy, who read a letter from Henri Le Chatelier. A full account of these addresses will be presented to the Society at the annual meeting in December by a Committee that represented the Society at the exercises, consisting of Henry R. Towne, F. R. Hutton, John R. Freeman and Oberlin Smith.

On Saturday the party met at Boxley, near Highland Station, Philadelphia, the former home of Mr. Taylor and was shown about the house and grounds.

## ENDORSEMENT OF THE BOILER CODE BY THE NATIONAL ELECTRIC LIGHT ASSOCIATION

An important coöperative movement in the introduction of the Boiler Code into legislative channels in the various states, is the recognition given at a recent meeting of the National Electric Light Association in approving the action of the American Uniform Boiler Law Society in its work of securing the general adoption of the Boiler Code recently formulated by a Committee of The American Society of Mechanical Engineers. The National Electric Light Association has appointed John Hunter, member of the Council of the Am. Soc. M. E., as its representative to serve on the executive committee of the American Uniform Boiler Law Society, who is expected to be particularly able in securing the coöperation of member companies of the National Electric Light Association in any state where the adoption of the Code is being agitated.

## COLLEGE REUNION NIGHT AT THE ANNUAL MEETING

During the last few years a very pleasing arrangement has been made whereby those attending the Annual Meeting who are graduates of one of the technical colleges have enjoyed a reunion of their Alumni Association. This year College Reunion Night will occur on Friday, December 10, and arrangements are under way for reunions of alumni of the following colleges: Brown University, Cornell University, Massachusetts Institute of Technology, Polytechnic Institute of Brooklyn, Purdue University, Rensselaer Polytechnic Institute, State University of Kentucky, Stevens Institute of Technology, Worcester Polytechnic Institute and Yale University.

The Society will be pleased to place at the disposal of any college alumni organization the facilities of the office or publications to develop reunions in connection with the coming Annual Meeting, and such organizations are invited to correspond with the Secretary. The large number of engineering graduates visiting New York at that time of the year offers an excellent opportunity for successful reunions.

# APPLICATIONS FOR MEMBERSHIP

## TO BE VOTED FOR ON DECEMBER 1, 1915

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages would qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of grading are also posted.

*The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned.* All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The candidates will be balloted upon by the Council unless objection is received by December 1, 1915.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Aeberli, J. Adolf, Ch. Hyd. Engr., Canadian Allis-Chalmers Ltd., Toronto, Canada

Arnaiz, Walter P., Ch. Draftsman, The Amer. Pulley Co., Philadelphia, Pa.

Barnes, Frederick A., Mech. Engr., Geo. S. Riderand Co., Cleveland, Ohio

Britton, William M., Elec. and Mech. Engr., Q. M. Corps, U. S. Army, Washington, D. C.

Brotherhood, Rowland S., Asst. Engr., Internatl. Silver Co., Meriden, Conn.

Campbell, Edmund D., Asst. Ch. Estimator, Passenger Car Dept., Amer. Car & Fdy. Co., St. Louis, Mo.

Carlson, John A., Indus. Engr., Remington Typewriter Wks., Ilion, N. Y.

Deulinger, Benjamin G., Mech. Foreman, Astoria Light, Heat & Pwr. Co., Astoria, L. I., N. Y.

Edwards, Oliver C., Instr. in Mech. Engrg., Univ. of Minn., Minneapolis, Minn.

Ferrari, Carl, Mech. Engr., Erie City Iron Wks., Erie, Pa.

Gifford, George B., Mgr. Bayonne Wks., Standard Oil Co., Bayonne, N. J.

Kennedy, William J., Ch. Engr., Genl. Dept., Boston Edison Co., Boston, Mass.

McAdam, John V., Pres., Revolute Mch. Co., New York.

McLean, Donald M., Mech. Engr. and Designer, Dover Boiler Wks., Dover, N. J.

Mabey, Arthur R., Foreman Thermometer Dept., Bristol Co., Waterbury, Conn.

Mistele, Henry J., Ch. Engr., Pwr. Dept., The Falk Co., Milwaukee, Wis.

Moul, Harry A., Cons., Contr., and Efficiency Engr., Philadelphia, Pa.

Nyrop, Michael J. F., Mech. Engr., General Elec. Co., Lynn, Mass.

Otis, Robert B., Directing Engr. in charge of Dept. of Engrg., Central Continuation Schools of Milwaukee, Milwaukee, Wis.

Peters, Heber C., Dist. Mgr., The Adder Mch. Co., Wilkes-Barre, Pa.

Proctor, Alfred W., Cons. Mech. Engr., New York

Rawson, William B., Safety Engr., Canada Cement Co., Ltd., Montreal, Can.

Ray, Edmund S., Ch. Engr., Francisco Sugar Co., Francisco, Camaguey Prov., Cuba.

Street, George L., Jr., Vice-Pres., J. R. Johnson & Co., Inc., Richmond, Va.

Thompson, James A., Mech. Supt., Brandram Henderson, Ltd., Montreal, Can.

Thomson, Samuel G., Supt. Motive Pwr. and Rolling Equipment, Penn. & Reading Rwy., Reading, Pa.

Weschler, George A., Assoc. Prof. Mech. Engrg. in Charge of Dept., The Catholic Univ. of Amer., Washington, D. C.

Westcott, Harry R., Supt. of Constr., The United Ill. Co., New Haven, Conn.

White, Louis E., Treasurer, Gale Mfg. Co., Albion, Mich.

Winge, Otto C., Specl. Designer with New Era Mfg. Co., New York

Wood, Fred L., Supt., Aeolian Co., Meriden, Conn.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bergstrom, Harry E., Round House Work Foreman, Nor. Pacific Rwy., Duluth, Minn.

Binckes, Frederick J., Instr. Mech. Drawing and Mech. Design, The Central Tech. School, Toronto, Canada

Bowles, John D., Elec. Supt., Springfield Gas & Elec. Co., and Springfield Traction Co., Springfield, Mo.

Callahan, Thomas E., Genl. Foreman, Bearing Dept., Doehler Die Casting Co., Brooklyn, N. Y.

Carver, Fred S., Cons. Engr., Newark, N. J.

Cuervo, Manuel V., Mem. of Firm, Cuervo & Pagliery, Cons. Engrs., and Dealers in Mchy., Havana, Cuba.

Estrada, Rafael, Jr., Asst. Engr., United Gas & Elec. Corp., New York.

Ford, Everett L., Factory Supt., Frank Mossberg Co., Attleboro, Mass.

Gladeck, Frederick C., Ballistic Engr., American Ammunition Co., Inc., New York.

Gould, Merle E., with Hyatt Roller Bearing Co., Harrison, N. J.

Hutchinson, John A., Engr., Internatl. Silver Co., Meriden, Conn.

Jellum, Kristen, Designing Engr., Winslow Safety High Pressure Boiler Co., Chicago, Ill.

Johnstone, Edward J., Chem. Engr. for Prof. F. M. Williams, Cons. Chem. Engr., Watertown, N. Y.

Pirie, Hugh L., Insptr. of Ordnance Mchy., in charge of No. 1 Traveling Workshop, British War Office, 1st Corps B. E. F., France.

FOR CONSIDERATION AS JUNIOR

Austin, Richard S., Asst. Mech. Engr., Cott-a-lap Co., Somerville, N. J.

Ballou, John M., Draftsman, The Babcock & Wilcox Co., Bayonne, N. J.

Bickley, Creighton D., Ordnance Insptr., Projectile Dept., Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa.

Bolton, John W., Jr., Mech. Engr., Eagle Knife & Bar Co., Lawrence, Mass.

Bower, Robert S., Mech. Dept., The River Furnace Co., Cleveland, Ohio

Briggs, Hermon B., Instr. in Mech. Drawing, The North Carolina College of Agri. and Mech. Arts, W. Raleigh, N. C.

Chew, John J. 2nd., with Remington Arms & Ammunition Co., Bridgeport, Conn.

Conard, Frederick U., Asst. Foreman, Fast Warp Dept., Jennings Lace Wks., Brooklyn, N. Y.

Cornwell, Eugene W. K., Engr., Keystone Forging Co., Northumberland, Pa.

Dabney, John C., Jr., Supt., Glamorgan Pipe & Fdy. Co., Lynchburg, Va.

Danforth, Thomas D., Mech. Engr., U. S. Radiator Corp., W. Newton, Pa.

Davis, John R., Asst. Foreman of Sacking Room and Warehouse, United States Gypsum Co., Oakfield, N. Y.

Fales, Dean A., Grad. Mass. Inst. Tech., 1915, West Newton, Mass.

Fletcher, Harold W., Engr., Newark Spring Mattress Co., Newark, N. J.

Flohr, Ralph C., Efficiency Engr., The Amer. Tool Works Co., Cincinnati, Ohio.

Foley, Louis J., Tech. Statistician, Pierce-Arrow Motor Car Co., Buffalo, N. Y.

Greenman, Philip R., Valve Developing Engr., Detroit Lubricator Co., Detroit, Mich.

Hess, Alexander M., Automatic Mchy. Designer, E. Kramer Mch. Co., Carlstadt, N. J.

Iler, William T., Jr., Student Apprentice, H. W. Johns-Manville, Manville, N. J.

Ingersoll, Howard H., with The Atlantic Refining Co., Providence, R. I.

James, Richard M., Rate Setter, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Kemp, Henry D., Formerly Asst. Mgr. Foreign Dept., Mead-Morrison Mfg. Co., East Boston, Mass.

Lytle, Charles W., Co-ordinator and Instr., Mechanics Institute, Rochester, N. Y.

McKinney, William P., Machine Shop, Marion Steam Shovel Co., Marion, Ohio

McNeal, Daniel R., Turbine Engrg., Westinghouse Mch. Co., E. Pittsburgh, Pa.

Magee, John F., Engr., Alpha Portland Cement Co., Easton, Pa.

Matson, John J., Research, Leland Stanford Junior Univ., Cal.

Newby, Howard L., Ch. Draftsman, Ft. W. & D. C. R.R. Co., Childress, Tex.

Newman, Harry P., Asst. Foreman, Remington Arms & Ammunition Co., Bridgeport, Conn.

Porter, David B., Investigator, David Maydole Hammer Co., Norwich, N. Y.

Rebman, Charles G., Asst. Engr., Hess Bros., Inc., New York

Reckendorfer, John K., 2nd Asst. to Vice-Pres., Amer. Lead Pencil Co., Hoboken, N. J.

Sharkey, William E., Asst. to Ch. Engr., The Miami Cycle & Mfg. Co., Middletown, Ohio.

Smith, Edwin R., Rep. Fitchburg Mch. Works, Fitchburg, Mass.

Williams, Edward H., Grad. 1915, Mass. Inst. Tech., Boston, Mass.

## APPLICATIONS FOR CHANGE OF GRADING

### PROMOTION FROM ASSOCIATE-MEMBER

Selser, Thomas W., Mech. Engr., Inter-state Commerce Comm. of U. S. Govt., San Francisco, Cal.

### PROMOTION FROM JUNIOR

Bixby, William P., Constr. Engr., Public Service Elec. Co., Newark, N. J.

Crowell, William J. Jr., Ch. Chemist, Amer. Iron & Steel Mfg. Co., Lebanon, Pa.

Cushman, Frank Jr., Head of Dept. of Mech. Arts and Applied Science, Kansas City Polytechnic Inst., Kansas City, Mo.

Davis, Edwin H., Engr. and Designer, American Steam Pump Co., Battle Creek, Mich.

Dirks, Henry B., Instr. in Engrg. Drawing and Mch. Design, Princeton Univ., Princeton, N. J.

Donaldson, Stuart A., Mech. Asst. to Operating Mgr., Equitable Office Bldg. Corp., New York

Erlenkotter, Walter, Fuel Engrg. Chemist, in charge of Central Testing Lab'y, Bureau of Contract Supervision, City of New York.

Fraser, D. Ross, Vice-Pres. and Supt., Chicago Portland Cement Co., Oglesby, Ill.

Gildehaus, Richard F., Jr., Supervising Engr., Busch Interests, Anheuser-Busch, of St. Louis, at Dallas, Tex.

Hazleton, Robert T., Supt. and Head of Engrg. Dept., Cincinnati Milling Mch. Co., Cincinnati, Ohio

Heidelberg, Frederick M., Mech. Engr., Copper Queen Cons. Mining Co., Bisbee, Ariz.

Hirschland, Franz H., Vice-Pres. and Genl. Mgr., Goldschmidt Detinning Co., New York.

Hobbs, James C., Asst. to Supt. of Pwr. Stations, Duquesne Light Co., Philadelphia, Pa.

Husted, Clifford M., Asst. Supt., Eagle Works, Standard Oil Co. of N. J., Claremont, Jersey City, N. J.

Lang, Charles, N. Y. Mgr., C. H. Wheeler Mfg. Co., New York

Miller, Richard E., Mech. Engr., The J. W. Frazier Co., Cons. Engrs., Cleveland, Ohio

Moyer, Allen V., Mech. Engr., The George T. Ladd Co., Pittsburgh, Pa.

Newell, William, Ch. Safety Engr., State Ins. Fund, New York

Peper, John H., Jr., Mech. Engr., New York Transit Co., New York.

Ricketts, Edwin B., Engr. of Tests, The New York Edison Co., New York.

Ruppel, Richard, Ch. Engr., J. Byers Holbrook, Cons. Engrs., New York

Schenck, Charles, Wks. Mgr. and Ch. Engr., Elevator Supply & Repair Co., Hoboken, N. J.

Schoenijahn, Robert P., Mech. and Elec. Engr., Wilmington & New Castle County Bldg. Comm., Wilmington, Del.

Sturgis, William B., Asst. Ch. Engr., in charge of Constr. Dept., Nichols Copper Co., Laurel Hill, L. I., N. Y.

Walker, Frank A., Engr., with B. B. and R. Knight, Providence, R. I.

Wood, Thomas C., United States Inspector, The Panama Canal, Chicago, Ill.

Wilson, Robert A., Mas. Mech., Producers Oil Co., Houston, Tex.

Whipple, William, Supt., Cinclare Central Factory, Cinclare, La.

## SUMMARY

| | |
|---|---|
| New applications | 80 |
| Applications for change of grading | 29 |
| Total | 109 |

# SAN FRANCISCO MEETING

*THE two papers presented at the first session, September 16, of the September meeting of the Society held at San Francisco in connection with the Panama-Pacific International Exposition and the International Engineering Congress were published in the October issue of The Journal. The three remaining papers, by Prof. W. H. Adams; A. H. Goldingham and Prof. G. H. Marx and L. E. Cutter, presented at the second session, September 17, are published in this issue. The paper by Professor Adams outlines very completely Diesel engine design and tendencies and considers the operation of this type of engine with various fuels. Mr. Goldingham's paper embraces heavy oil engines, both of the Diesel and hot surface types, and includes new cost data. Professor Marx and Mr. Cutter's paper on gear teeth throws light upon the question of allowable stress for modern cut cast-iron gear teeth.*

## THE DIESEL ENGINE AND ITS APPLICATIONS IN SOUTHERN CALIFORNIA

BY WALTER H. ADAMS, PASADENA, CAL.

Member of the Society

DIESEL secured his first patents in 1893, and brought out his first successful engine in 1897, at the Augsburg Works in Germany, and since the latter date the use of the Diesel engine has been increasing steadily, especially in Europe. Several well-known steam engine manufacturers in the United States today have begun the manufacture of Diesel engines, thus showing a growing demand in this country for such a prime mover. There are comparatively few Diesel engines in the United States at present, the total horsepower in use being just over 100,000, but the number is increasing rapidly every month.

Diesel's original patent described the action of his engine as follows: (*a*) The highest temperature is that due to the compression of air only and this may be regulated by making the compression the desired amount. (*b*) Into this air is introduced the fuel, gradually, in a finely divided state and in such quantity that the burning offsets the cooling due to the expansion as the piston moves forward.

This was the original idea of Diesel, namely, a supply of heat at constant temperature. Such a supply would fulfil one of our thermodynamic conditions for maximum efficiency —a supply of heat at a constant maximum temperature. Diesel's engine in practice did not give this desired result, so he modified his statement to cover an increase in temperature during the admission of the fuel, this increase in temperature taking place at constant pressure. This is the condition of the Diesel engine today, as closely as it is possible for the actual engine to meet the ideal conditions.

The difference between the Diesel engine cycle and that of the standard form of internal combustion engine (Otto) is shown in Fig. 1. In the Otto cycle there is compression from $A$ to $B$; ignition and burning at constant volume from $B$ to $C$; expansion from $C$ to $D$; and rejection of heat to the exhaust, at constant volume, from $D$ to $A$. (It makes no difference in the ideal diagram whether the engine is 2- or 4-cycle.) In the Diesel engine there is corresponding compression from $A$ to $B$; then burning at constant pressure from $B$ to $C$; expansion from $C$ to $D$ and exhaust at constant volume from $D$ to $A$. In the Otto cycle there is an explosion while the volume remains constant, thus increasing the pressure and temperature; in the Diesel cycle there is burning at constant pressure while the volume and temperature increase.

The expressions for the thermal efficiency of the ideal cycles are also shown in Fig. 1, and curves plotted from these equations are given in Fig. 2. The most interesting thing to observe from these curves is that, for corresponding pressures at the end of compression, the Diesel engine has the lower thermal efficiency. This is offset by the fact that in the Otto engine the limit of compression pressures is 80 to 200 lb. per sq. in., while in the Diesel engine the compression may be carried as high as desired. The reasons for this are that in the Otto engine the fuel is compressed with the air, and pre-ignition will take place if the compression is carried too high, due to increase of temperature with increase of pressure. In the Diesel engine, air only is compressed and the temperature may rise as high as desired without danger of pre-ignition. The temperatures due to compression are shown in Fig. 3. At a pressure of 500 to 550 lb. per sq. in. the temperature is about 1000 deg. fahr., and if fuel in a finely divided condition is introduced into air at this temperature, it will take fire and burn without any special ignition apparatus.

Fig. 3 was calculated for an adiabatic compression. There is considerable discussion as to what is the corre t exp for this curve as it varies with different engines; therefore the ideal curve is used. The actual temperatures would agree approximately, as the new charge of air is heated above 100 deg. fahr. by the hot cylinder walls and by mixing with the burnt gases in the clearance space. This makes a higher initial temperature although the compression curve is flatter than the ideal.

High compression is possible with the Diesel engine with corresponding gain in efficiency, and at the same time there is more complete combustion of the fuel because of the finely divided state in which it is forced into the cylinder. The maximum possible efficiency for the Otto engine is 52 per cent for blast furnace gas and 44 per cent for a motor car engine. Against this there is 57 per cent efficiency for the Diesel engine, a gain of 29 per cent over the motor car engine and 11 per cent over the blast furnace gas engine. If the Otto engine could have the same compression, it would be a better engine than the Diesel engine.

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Presented at the Panama-Pacific International Exposition meeting, San Francisco, September 1915, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Contributed by the Los Angeles Section. The paper may be obtained in pamphlet form; price 10 cents to members, 20 cents to non-members.

This question may be asked: Why cannot the efficiency of the Diesel engine be further increased by higher compression than 500 to 550 lb. per sq. in.? This is possible in the ideal engine, but experience has shown that 600 lb. per sq. in. is the highest allowable pressure in the actual engine. For pressures above that amount, the increased size of the parts of the engine increases friction and cost above any gain in theoretical efficiency. Changes in the Diesel engine will have to be more along the line of reduced cost and simpler design rather than better economy.

### 2-cycle and 4-cycle internal combustion engines

The difference between the 2-cycle and 4-cycle types of internal combustion engine is in design and construction and not in theory.

In the 2-cycle engine there is expansion of the burnt gases until near the end of the stroke; then exhaust begins and almost simultaneously there is admission of either air and fuel or air alone at another part of the cylinder—this admission taking place under slight pressure. The burnt gases are forced out by the fresh charge, the piston moves back and compression takes place. This gives one working stroke for every revolution, just as in a single-acting steam engine. The necessary compression of the inlet air is supplied by the slight compression produced by the piston in an enclosed crank case (cheap engines), or is produced by a separate scavenging air compressor, as in all 2-cycle Diesel engines. In this type the pressure of the air is not carried to more than 4 to 8 lb. per sq. in. above atmospheric.

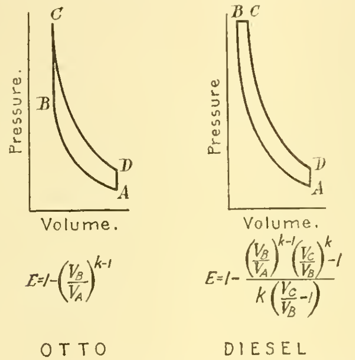



Fig. 1 Comparison of Cycles and Thermal Efficiencies

In the 4-cycle type there are ignition and expansion until the end of the stroke. Then the exhaust valve opens and remains open until the piston has moved back, thus allowing the piston to expel the burnt gases. The exhaust valve closes and the admission valve opens, remaining open while the piston moves forward to draw in a fresh charge. It then closes and compression takes place. This complete cycle requires two revolutions of the engine and in practice necessitates a large flywheel or a multiple-cylinder engine if the speed is to be kept constant.

There are advantages and disadvantages for both types applied to Diesel engines. The 2-cycle type gives almost twice as much power for the same size of cylinder, as it has two working strokes for one in the 4-cycle. (Actual value is 170 to 180 per cent.) This means less weight, space and first cost. As usually constructed, the piston acts as its own valve and so air inlet and exhaust valves are not required. (This is not true of some of the better class of 2-cycle Diesel engines, as will be explained later.) In marine work the reduction in number of valves makes it easier to reverse a 2-cycle engine. The use of the 2-cycle type has also made large units possible, and 1200 h.p. per cylinder in a single-acting engine has been built.

On the other hand there is to be said for the 4-cycle type of Diesel engine:

*a* It is older than the 2-cycle type and so has become a more stable contruction

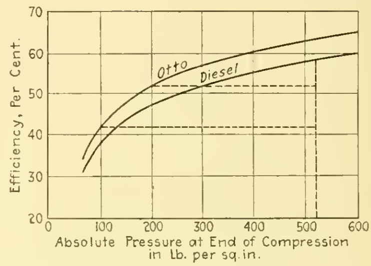



Fig. 2 Comparison of Efficiencies, Otto and Diesel Engines

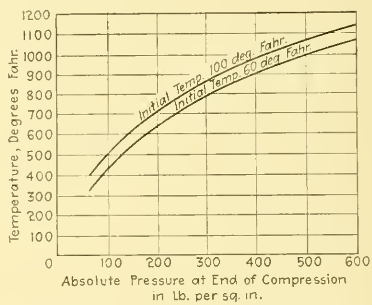



Fig. 3 Diesel Engine Compression Temperatures

*b* It gives better fuel economy, as expansion can be carried to the end of the stroke and no power is required for the scavenging pump. The gain is about 10 per cent

*c* The mean temperature is lower. There is more time to remove the heat and not so much heat to remove per unit of cylinder surface. (In a 2-cycle engine 90,000 B.t.u. per hour has to be removed for every square foot of cylinder surface. In 4-cycle engines the figure is 40,000 B.t.u. In an ordinary water-tube boiler working at 300 per cent of rating, it is 10,000 B.t.u.)

*d* The valve gear runs at one-half the speed of the main shaft

*e* In the high speed 2-cycle engine, it has been difficult to get the burnt gases out of the cylinder in the short time available, so that such engines have not been quite as successful as 4-cycle engines.

The tendency in this country and abroad is to use 4-cycle engines up to from 700 to 1000 h.p. and above that 2-cycle. This is due to the reduced first cost of the 2-cycle type in

the large sizes and the excessive diameter of cylinder required in large 4-cycle engines. As progress is made in design, the 2-cycle type may supersede the 4-cycle, but this is not evident at present in the smaller sizes.

### APPLICATIONS OF THE DIESEL ENGINE

The Diesel engine is in use today in almost all places where a steam engine or turbine might be used. Its starting torque is poor and it should run at a constant speed, although this may be varied to some extent. The rated load decreases as the altitude at which the engine operates is increased.

The engine is being employed for propelling ships of over 400 ft. in length and 9000 tons in cargo capacity, at a speed of about 11½ knots; such ships are twin-screw and have engines of 1600 b.h.p., developed in 6 cylinders. The engine has not been used for high speed passenger ships. It has been used in many sailing vessels to provide auxiliary power in calm weather. It has been used in submarines, and the Craig Shipbuilding Company is now building for the United States Government some submarines which are to be equipped with Busch-Sulzer Diesel engines.

One locomotive equipped with Diesel engines has been built in Europe, but it was large, clumsy and not very successful. Diesel locomotives will not compete with steam locomotives at present. For isolated plant or central station service the Diesel engine is well adapted, if several units are installed so that each unit will work near its rated load without a heavy overload under all conditions of load factor.

The Diesel engine gives excellent service when installed as a pumping engine. It can be used for all kinds of factory service just as well as the steam engine. The reasons why it is not adopted more extensively in this country are probably:

1 The availability of cheap fuel has prevented a demand for an expensive first cost prime mover that will give decreased operating cost
2 American manufacturers have been slow to take up the manufacture and introduction of these engines
3 Engines giving satisfactory service have only been made in Europe within the last five years
4 A Diesel engine requires extreme care in manufacture and in adjustment, particularly of the fuel valve
5 The engine cannot be operated without careful supervision when the cleaning and adjusting are going on
6 Some prejudice exists against all forms of internal combustion engines due to the multiplicity of causes that may prevent their starting
7 Oil must be used as fuel, and the cost may vary within wide limits
8 Innate conservativeness of the human race makes it slow to adopt a new method or machine until others have tried it.

### DESIGN CHARACTERISTICS OF DIESEL ENGINES

It is my intention to discuss design characteristics in a general way, summing up the present situation, rather than to describe details of the various types. (Since the preparation of this paper was commenced, an excellent article[1] on the design of the Diesel engine has been published in The Journal.)

[1] Vol. 36, December, 1911, page 420. Recent Developments in the Manufacture of the Diesel Engine, H. R. Setz.

At present, engines are manufactured in this country in both the horizontal and vertical types. One to four cylinders are used in the horizontal and one to six cylinders in the vertical engines. The favorite size of the latter is two to four cylinders.

The horsepower per cylinder ranges from 30 to 250, with size of cylinder varying from 12 to 21 in. The stroke bore ratio is about 1.25. (In December one manufacturer announced a 4-cylinder vertical engine of 2500 b.h.p.).

The smallest Diesel engine (dimensions of cylinder) that the author finds any record of is a 6¾ by 8⅝ in., 2-cycle, 4-cylinder engine, developing 110 b.h.p. at 550 r.p.m. The largest engine is a 32.2 by 39.4 in., 2-cycle, single-cylinder

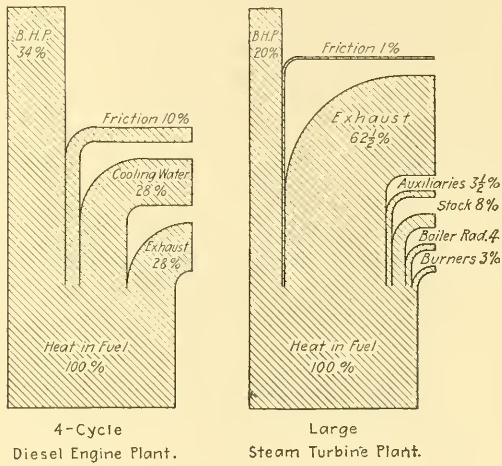



Fig. 4 Comparison of Heat Balances

engine, developing 1250 b.h.p. at 150 r.p.m., m.e.p. 106 lb. per sq. in. This latter is an experimental engine built by Carels Bros. in Belgium. If such an engine were built with 8 cylinders, it would have an output of 10,000 b.h.p., which would compare favorably with a steam turbine, if the space occupied be neglected.

The engines built in the United States are all comparatively slow speed, ranging from 150 to 300 r.p.m., with piston speed of 600 to 900 ft. per minute. A few high speed marine engines have speeds as high as 480 r.p.m. In Europe, before the war started, there was being developed a line of high speed engines with a speed of 550 r.p.m. for submarines and such work. The highest commercial speed in use at present is 350 to 400 r.p.m.

All engines, except one make, are single-acting. (One manufacturer reports the making of a double-acting engine, but I should judge that this has not been tried out thoroughly.) In Europe several firms were experimenting on a double-acting engine; the trouble experienced in this type is in cooling the cylinder and piston and keeping the stuffing boxes tight.

All engines in this country, except two makes, embody trunk pistons without crossheads. In Europe several marine

types use a crosshead, but all others employ the trunk piston. The crosshead takes the wear produced by the angular thrust of the connecting rod.

*Valves and Valve Gear.* There is necessarily considerable difference in the design of valves and gear of the 2-cycle and 4-cycle types. As the piston acts as its own valve in the high speed 2-cycle type, there are only two valves in the cylinder head—the fuel valve and air starting valve. In the better slow speed 2-cycle engines there are 7 valves in the cylinder head; these are 4 scavenging valves, 1 fuel valve,

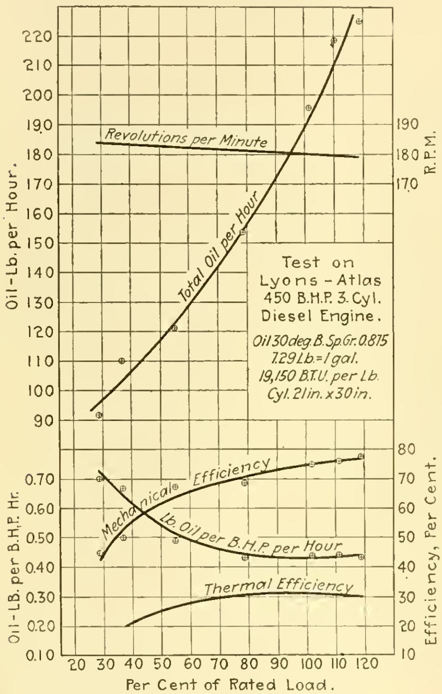



Fig. 5 Results of Tests on 3-Cyl. Lyons-Atlas Diesel Engine

1 starting air valve and 1 safety valve. (There are no American engines with 4 scavenging valves in the cylinder head.)

The 4-cycle engine must have at least 4 valves, namely, suction, exhaust, fuel and starting valves. The safety valve is often combined with the air starting valve. In most engines the valves are all placed in the head of the cylinder, but in a few types the suction and exhaust valves are placed on its circumference.

The material used for cylinder walls, liners, and heads is cast iron. A few engines have been equipped with cast steel heads, but these did not prove satisfactory and cast iron has been substituted.

*Fuel Valve.* The fuel valve in the Diesel engine is the most delicate part of it. Even when the engine is fully loaded, this valve moves only a few hundredths of an inch. In an engine with a 21 by 30 in. cylinder, the amount of oil per stroke at rated load is only 0.4 cu. in. When it is remembered that this oil must be introduced in the form of a very fine spray in a time of about 1/40 sec., and that the regulation of the amount of oil is the only method of governing the engine, it is easy to imagine the troubles of the early operators and designers. The fuel valve must not clog or fill with gum and must always operate correctly. The designs of the manufacturers vary in detail, but the underlying principle is the same. The fuel is pumped into a chamber surrounding the valve by a pump whose stroke is controlled by the governor; this chamber forms a labyrinth passage. Air under a pressure of 800 to 1000 lb. per sq. in. is admitted in back of the oil and forces the latter into the cylinder in the form of a fine spray. The valve is controlled by a cam, opening about 1 per cent before the end of the compression stroke and remaining open from about 8 to 10 per cent of the working stroke.

In most of the present engines, the oil is forced into the valve passages against the air pressure, thus requiring a strong oil pump. Several manufacturers have adopted the method of pumping the oil into a restricted passage between the air valve and the cylinder during the suction stroke of the engine, where it remains until the air valve opens and it is forced into the cylinder. This arrangement reduces the work of pumping. The relative merits of the two types are under discussion today. So far as the author can find ont the low pressure type seems to give the best satisfaction with California oils. At least the manufacturers using this type say they can use any grade of oil, while the manufacturers of the high pressure type like to specify a minimum grade of oil that they can use.

The remainder of the design of the Diesel engine follows gas engine design quite closely, with generally more massive and careful construction. It is discussed more fully in the paper quoted above.

*Air Compressor.* The air used for spraying the oil into the cylinder is supplied by a 2- or 3-stage air compressor. The pressure required for the spray is 800 to 1100 lb. per sq. in., depending mainly upon the kind of oil used, but also to some extent on the load under which the engine is working. The amount of this air is estimated to be from 16 to 34 cu. ft. of free air per b.h.p. per hour. The power required for operating the compressor is about 4 to 7 per cent of the total power developed by the engine. The compressor is usually made an integral part of the engine, and is driven by a crank forged on the crank shaft. In a few cases it is driven by a belt from the engine or by a motor.

*Scavenging Pump.* In the 2-cycle engines a special scavenging pump is used for driving the burnt gases ont of the cylinder. This is usually made the low pressure stage of the air compressor. As previously mentioned, the scavenging air is controlled by the piston or by scavenging valves in the cylinder head. This latter type gives the best scavenging, as the air sweeps through the cylinder from the head end, and passes out through ports placed around the circumference at the crank end. There is a large gain in economy and power due to using this scavenging air in the 2-cycle engine, because of better combustion, but it is not necessary in the 4-cycle engine.

The air is supplied at a pressure of 4 to 8 lb. per sq. in. above atmosphere. The volume of this air is from 1.2 to 1.8 times the cylinder volume. The power required for the pump

is approximately 4 per cent of the output of the engine.

*Governing.* The governing is by a governor which regulates the amount of fuel supplied to the engine. The governor holds the suction valve of the fuel pump open for a portion of the forcing stroke, or regulates the length of the stroke of the pump, or varies the clearance of the pump. Each manufacturer employs a different method for governing, but all methods in use seem to give a close regulation. If the engine has more than one cylinder, each cylinder must have its own pump and all pumps must be under the control of the governor. As far as the author knows, no one has attempted to distribute the oil to the various cylinders after it leaves a common fuel pump.

The regulation is well under 3 per cent in all types, and, if necessary, some manufacturers are willing to guarantee much closer regulation. All engines, except the single cylinder types, will give close enough regulation for operation of all electrical machinery. The overload capacity of the Diesel engine is small when compared to turbines as it is only about 10 to 15 per cent.

*Water Cooling.* The cylinders and cylinder heads of all Diesel engines must be watercooled, and in the larger sizes the pistons must be cooled also. The amount of water required is about 3 to 9 gal. per b.h.p. per hour, depending upon the temperature rise which is allowed. With a temperature rise of 70 deg. fahr. the amount of water will be about 3 to 4 gallons. The maximum temperature of the cooling water is kept about 130 to 140 deg. fahr., although it may rise to as high as 180 deg. fahr. if the water contains no impurities that will precipitate at this temperature. The heat carried away in the cooling water is about 2500 to 3000 B.t.u. per b.h.p. per hour.

FUELS

Any fuel that will burn without leaving an ash or residue, either due to incomplete combustion or due to unburnable material in the fuel, may be used in a Diesel engine. Attempts have been made to introduce pulverized coal into the cylinder of the engine, but these have not as yet been successful. Gasoline, kerosene and the light distillates need not be considered as fuel for the Diesel engine as they can be used to better advantage elsewhere.

There is left crude oil, low-grade distillates and the coal tar products. The last have not been used to any great extent in this country.

Crude oil which is free from sand and water can be used as fuel, even if it contains as much as 50 per cent asphaltum. Owing to the scarcity of gasoline, today practically all crude oil has the gasoline content removed before it is sold for fuel, so that all fuel oil is "topped" oil.

On the Pacific Coast we are not interested in the Eastern oils, but I would like to say that when used in Diesel engines these have given better satisfaction than the Western oils. The California oils have been tried on the manufacturers' testing floors in the Eastern states, and all reports that the author has received indicate that they have been satisfactory. But, at the same time, the statement is made that the tests have not been continued for more than 6 to 7 days as the supply of the special oil becomes exhausted. After such tests the condition of the engine is always reported to be excellent. The objections that the author has heard against the Western crude oils are these: Viscous and sluggish, high sulphur content, high water content, and high in ash.

A viscous and sluggish oil can be heated by the cooling water as it leaves the engine, or by the hot exhaust gases, until it becomes fluid. It can then be pumped as well as any oil. When such an oil is employed kerosene should be used to start up with and for a few minutes before shutting down, so as to clean out all the heavy oil from the piping and pumps.

The high sulphur content oil is more dangerous, as it burns to sulphur dioxide which tends to cause corrosion of the piston and cylinder, the valves and valve seats and the exhaust pipe. The maximum amount of sulphur that can be allowed seems to be about 2 to 4 per cent.

Water in the oil will decrease the heating value and cut down the amount of fuel delivered to the cylinder. If the water comes in "slugs" it will cause the engine to run irregularly. "Topped" oil will not contain much water, as it will be removed during the topping process. Most manufacturers specify an oil containing less than 1 to 2 per cent of water.

The ash is of considerable importance as it tends to remain in the cylinder, causing cutting of the walls, the valves and the valve seats. This makes the maintenance

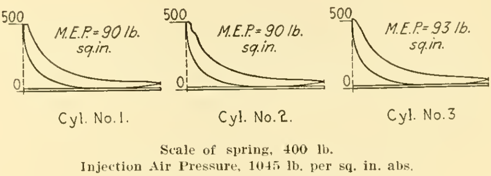



FIG. 6 INDICATOR CARDS FROM 3-CYL. LYONS-ATLAS DIESEL ENGINE

charges high. The Eastern paraffine base oils can be cleaned much easier than the Western asphaltum base oils. In the latter the asphalt collects around the sand particles, and it is impossible to separate them except by heating the oil and straining it while hot.

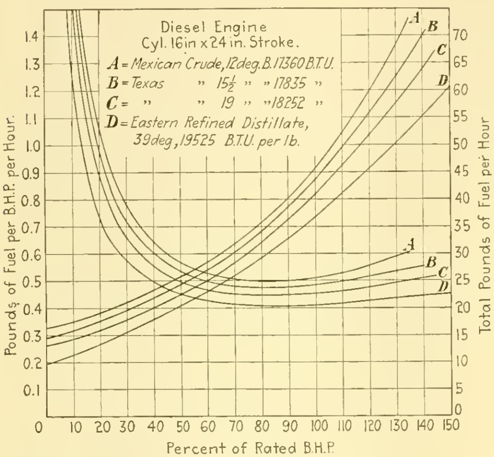
Some engines are working today on Western oils being sold in the market as boiler fuel oil. The Diesel engine located on the Jameson ranch at Corona, Cal., is now runing on 24 to 26 deg. Beaumé Santa Fé tops bought for the smudge pots. The oil costs 69 cents per barrel, f. o. b. Los Angeles. This engine has been run for more than 2 months without a shut-down. About a quart of coal oil was supplied twice a day to clean out the pump. The engine was run for 10 days on 18 deg. fuel oil then in use on a steam road roller in Corona, and the run was stopped at the end of that period, as the supply of that particular fuel was exhausted.

The Lyons-Atlas Company sold a 600 b.h.p. engine to the Hawaiian Commercial and Sugar Company on the guarantee of 710 hours operation out of 720 per month on 14 to 18 deg. California oil, then in use under the company's boilers in the Hawaiian Islands. The engine was tested at the factory under the supervision of the company's engineer, was paid for, and then shipped through the Panama Canal to the Islands. The test consisted of a 48-hour preliminary run on Eastern oil and then a 144-hour (6 day) continuous run at

rated load on the California oil. At the end of the run, the valves and the heads were examined and no evidence of any deposit was found. A 120 h.p. 4-cycle engine has been running for 6 months, 24 hours a day, without a stop, in San Antonio, Texas. The fuel was a 20-deg. Texas oil. There are numerous other examples of engines on this coast, but not using California oils. Many engines are in operation in Texas, New Mexico and Arizona using Texas and Mexican oils.

### ECONOMY AND EFFICIENCY

The economy of the Diesel engine is the best of all present engines. Fig. 4 shows the heat balance for a 4-cycle Diesel




Curves starting lower left hand corner show total fuel

Fig. 7 Diesel Engine, Comparison of Fuels

engine, and also for one of the latest large steam turbine plants. In preparing this heat balance for the Diesel engine, a mechanical efficiency of 77 per cent was assumed and the thermal efficiency of an actual engine, as shown by test, was used as a basis for the remainder. The distribution of waste heat between exhaust and cooling water for this engine varies, so that an equal distribution was assumed.

The heat balance of the turbine plant is a composite heat balance based upon an oil-fired boiler and a turbine generator unit, using the best steam figure that I have record of; 95 per cent is allowed for the efficiency of the generator and 95 per cent for the mechanical efficiency of the turbine.

The author's idea in making this comparison is to show the best thermal efficiency in both types of prime movers, thus indicating the superiority of the Diesel engine as far as thermal efficiency is concerned. So far as is known, however, no steam turbine plant is operating today with an overall thermal efficiency quite as high as the 20 per cent shown.

The efficiency of the Diesel engine may be still further increased by utilizing the heat in the exhaust for making steam to run a steam turbine. Experiments are now being carried out in this direction, but the results are not yet good enough to indicate that this can be done in all cases. Experiments are also being made along the line of increasing the temperature of the jacket water, so that this may be converted into steam which may be used.

Figs. 5 and 6 show respectively efficiency curves and indicator cards for a 3-cylinder Lyons-Atlas Diesel engine, using an Eastern oil. Fig. 5 shows clearly that from about 60 per cent to 120 per cent of the rated load the economy and thermal efficiency remain nearly constant. The mechanical efficiency tends to increase as the load increases. This factor is about 75 per cent at full load for a 4-cycle engine and 70 per cent for a 2-cycle engine. (This is due to the power required for the air compressor for the scavenging air.)

Fig. 7 shows the results of a series of tests on an engine, using various fuels. When the best grade of fuel indicated is used, the amount is about 0.4 lb. per b.h.p-hr., while it does not exceed 0.5 lb. with the poorest grade at rated load.

The Diesel engine will work nearer to test conditions at all times than any other type of prime mover, as it is more independent of the operator and requires a good compression for ignition. The efficiency depends upon the compression; if

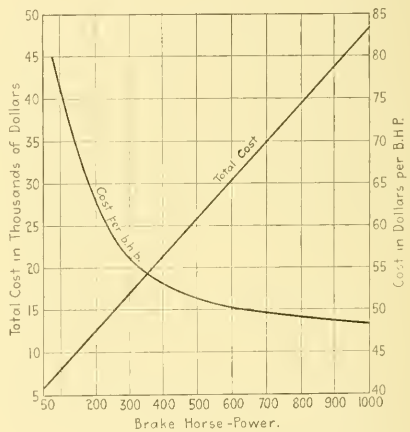



Fig. 8 Cost of Diesel Engines, f.o.b. Los Angeles, Cal.

this latter drops due to valve trouble the engine will show it at once, as there will not be heat enough to ignite the fuel.

### OPERATING AND DEPRECIATION

The amount of lubricating oil is stated to be about 0.01 pint per b.h.p. per hour, based on the rated load. The engine at Corona uses 3 quarts of oil every 24 hours to supply the loss. The load is about 35 h.p. while the rating of the engine is 65 h.p. This is at the rate of 0.008 pint per h.p. per hour.

One engineer can handle 1000 to 1500 horsepower per shift. The attendance consists in keeping the engine supplied with both fuel and lubricating oil and the minor work that there always is around a power plant. Operators and manufacturers say that it is necessary to examine the fuel valve and the exhaust valves periodically and clean them. The time interval for this depends upon the kind of fuel in use—it may be a week or several months.

The question of maintenance and depreciation is still an open one. The maintenance charges per year seem to average

about 1 per cent of the first cost of the engine. Very few manufacturers have yet had engines in service for any length of time, so that the life of the engine is still uncertain, although it is claimed to be longer than that of a steam engine. The Busch-Sulzer Diesel Engine Company have two 225 b.h.p. engines installed in Texas which were put in over nine years ago; these have been operating on an average of 18 hours a day. The cylinders have never been rebored and now show very little wear and are as smooth and bright as glass. The same company also has a 225 b.h.p. engine in Illinois which has been working for 24 hours a day, 6¾ days a week, for over 2½ years, with only two minor shut downs.

The following facts seem to be fairly well established:

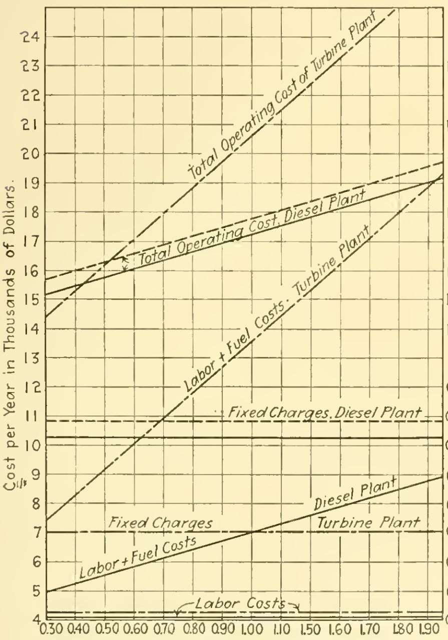



Fig. 9 Comparison Cost Curves, Steam Turbine and Diesel Engine, 600 kw. Municipal Lighting Plant

1 The Diesel engine can operate continuously for 6½ or more days out of seven
2 This can be kept up for long periods if a short interval is allowed for overhauling and minor repairs
3 The exhaust valves may give trouble by burning if the load is too large
4 The air compressor may give more trouble than the engine if it is not watched
5 Dirt in the oil will give trouble
6 Water in the oil will give trouble
7 The engine will not carry much more than its rated load for any length of time.

### Weights and Costs

The weight of the Diesel engine per horsepower varies considerably, even for the same size of engine. Data supplied by the manufacturers in this country show that the weight per b.h.p. varies from 250 to 500 lb., with no uniformity, except that the higher-priced engines are the

TABLE 1 COMPARISON COSTS, STEAM TURBINE AND DIESEL ENGINE, 600 KW. MUNICIPAL POWER PLANT

ASSUMPTIONS

Load Factor = 25 per cent Maximum load = rated output
(This gives turbines slight advantage in overload capacity)
Turbines operated condensing, using jet condenser and cooling tower. Oil Fuel.
Crude oil, 95 cents bbl. Distilled oil, $1.50 bbl.
Turbine Plant develops 140 kw-hr. per bbl.
Diesel Plant develops 447 kw-hr. per bbl.

FIRST COST

| Turbine Plant | | Diesel Engine Plant | | | |
|---|---|---|---|---|---|
| 1-200 kw., 1-400 kw. Units | | 3-200 kw. Units | | 1-200 kw., 1-400 kw. Units | |
| Boilers & Settings | $ 6,200 | Engines | $51,000 | Engines | $47,500 |
| Pumps | 250 | Erecting | 5,000 | Erecting | 5,000 |
| Piping | 500 | Piping | 1,400 | Piping | 1,400 |
| Stack and Flues | 2,950 | Oil tanks | 1,000 | Oil tanks | 1,000 |
| Heaters | 500 | Water Cooling Apparatus | 1,000 | Water Cooling Apparatus | 1,000 |
| Turbines | 12,500 | | | | |
| Generators, etc. | 11,400 | Generators | 11,400 | Generators | 11,400 |
| Condensers | 2,400 | Building | 6,000 | Building | 6,000 |
| Cooling tower | 3,500 | | | | |
| Building | 10,000 | | | | |
| Total | $50,200 | Total | $76,800 | Total | $73,300 |

OPERATING COSTS, 1,314,000 kw-hr. per Year

| Turbine Plant | | Diesel Engine Plant | | | | |
|---|---|---|---|---|---|---|
| Wages | $3,000 | Wages | $3,000 | | | |
| Lubrication | 500 | Lubrication | 500 | | | |
| Miscellaneous | 100 | Miscellaneous | 100 | | | |
| Maintenance | 400 | Maintenance | 400 | | | |
| Water | 250 | Water | 50 | | | |
| | $4,250 | | $4,050 | | | |
| | | | 3 Engines | | 2 Engines | |
| | | | Fuel | | Fuel | |
| | | | 95 cents bbl. | $1.50 bbl | 95 cents bbl. | $1.50 bbl. |
| Fuel at 95 cents per bbl. | $8,910 | Fuel | $ 2,790 | $ 4,410 | $ 2,790 | $ 4,410 |
| Fixed charges 14 per cent | 7,030 | Fixed Charges 14 per cent | 10,780 | 10,780 | 10,280 | 10,280 |
| Total | $20,190 | Total | $17,620 | $19,240 | $17,120 | $18,740 |

Discussion of these Values

Difference in first costs = $73,300 − $50,200 = $23,100.
Diesel Engine Plant costs 46 per cent more.
Difference in operating costs.
(a) $20,190 − $17,120 = $3,070. Net saving per year = $3,070.
(b) $20,190 − $18,740 = $1,450. Net saving per year = $1,450

*Conclusion*: Difference in yearly cost is so small that no definite conclusion can be drawn.

Each plant should be investigated carefully before the type of equipment is decided upon.

heavier. In an issue of London Engineering during 1914, the statement was made that in European practice the weight had been reduced to 62 lb., but this was an exception.

The cost of the engine is hard to determine, as it varies so much and manufacturers do not like to supply cost data. The

price increases directly with size of engine from $6000 for a 75 h.p. engine to about $48,000 for a 1000 h.p. engine. The price of a small Diesel engine is prohibitive and that for large engines of several thousand horsepower does not go much below $45 per horsepower. Curves of costs plotted from data supplied by several manufacturers are given in Fig. 8.

### COST OF A SMALL PLANT

Table 1 shows a comparison of the cost of steam turbine and Diesel engine plants, 600 kw. The plants are suppositious, but the cost figures given can be considered as approximately correct. They show that the Diesel may enter into serious competition with the steam plant when the load factor is better than 25 per cent. The Diesel engine will not replace the steam plant until much more definite figures are secured regarding the life of the former.

As the yearly load factor is increased the Diesel engine will show a saving in total operating cost due to the saving in fuel. In the steam plant the fuel item is the largest single item of expense, with the fixed charges next. In the Diesel plant the fixed charges are the largest single item, with the remainder of the operating cost about equally divided between fuel and labor, water, etc.

The items under first cost of the two plants are only approximately correct, as the author had no personal data available and had to depend upon published results which did not check with one another. The output per barrel of oil is based upon published yearly reports of both Diesel and steam plants. The steam plant is located in California while the Diesel plant is in Texas. The distilled oil cost was purposely placed high, so as to indicate the showing that a Diesel engine could make in competition with a steam plant, even if it was handicapped with a high price of suitable oil. As we are not interested in comparison of coal and oil as fuels, no attempt has been made to show such. The items under operating cost were taken from a published report of a Diesel plant in Texas, where wages are low in comparison to those in California. In the turbine plant about the same conditions of operating have been assumed, as the total of the items listed under lubrication and miscellaneous are small.

In Fig. 9 showing cost curves are plotted the yearly costs for the plants against price of oil per barrel. This shows graphically the effect of the price of oil on the total operating cost. By projecting from the total operating cost curve of the steam turbine plant to the corresponding curve for the Diesel plant, a comparison may be secured for any price of oil. For example, assume the price of boiler fuel oil to be 75 cents and engine oil to be 90 cents per barrel. Then the turbine plant will cost $18,400 per year, and the Diesel plant $17,500 per year. When the price of oil is 53 cents per barrel, the yearly cost will be about the same for both plants.

On account of the lack of data relative to the life of the Diesel engine, the same fixed charges, namely, 6 per cent depreciation, 6 per cent interest and 2 per cent insurance and taxes, have been assumed alike for both plants for comparison.

The item of life of the Diesel engine is open for discussion, but no one can yet say definitely what the life of the Diesel engine, properly taken care of, is going to be, as none of our successful plants have been in operation long enough to give the answer.

# THE HEAVY OIL ENGINE, ITS PRESENT STATUS AND FUTURE DEVELOPMENT

BY A. H. GOLDINGHAM, NEW YORK

Member of the Society

SINCE the oil engine was invented, about 1870, rapid progress has been made with it. This is best demonstrated by reference to the indicator diagrams, Figs. 1 to 8, taken from engines built during the past twenty-seven years.

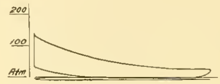



FIG. 1


FIG. 2


FIG. 3


FIG. 4

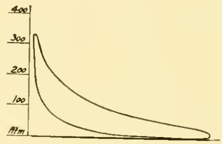



FIG. 5

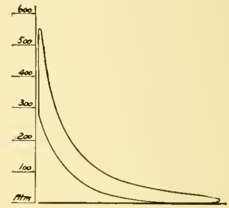



FIG. 6

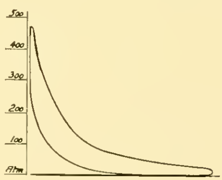



FIG. 7

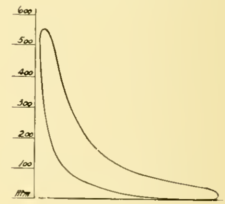



FIG. 8

INDICATOR DIAGRAMS SHOWING PROGRESS IN OIL ENGINES SINCE 1888

The first diagram was taken from a Priestman oil engine, 1888 type, cylinder $10\frac{3}{4}$ in. diameter, stroke 14 in., 160 r.p.m. The initial pressure was 125 lb. per sq. in., exhaust pressure 24 lb., compression pressure 20 lb. and m.e.p. 44 lb. The b.h.p. developed was 8.4, using fuel with a heating value of 19,000 B.t.u. and specific gravity 0.853. The fuel consumption was 1.05 lb. per b.h.p-hr. and the thermal efficiency 12.8 per cent. All these figures represent average conditions.

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*Author's Note: The distillate engine lorgely in operation in the Pacific Coast States is not discussed in this paper. Only engines using heavy fuels ore referred to.*

Presented at the Panama-Pacific International Exposition meeting, San Francisco, September 1915, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The paper may be obtained in pamphlet form; price, 10 cents to members, 20 cents to non-members.

The fuel was sprayed into an external vaporizer (separate from the cylinder), heated by the exhaust gases, the ignition being effected by an electric ignitor.

Fig. 2 is a card from a Hornsby-Akroyd engine, 1890 type, with hot-surface vaporizer constructed without the partial water jacket of later engines, and with very low compression pressure. The engine represented developed 6 b.h.p. at 216 r.p.m., with fuel having a heating value of 19,000 B.t.u. and specific gravity 0.8410. Fuel consumption 1.0 lb. per b.h.p-hr. and thermal efficiency 13.5 per cent. The initial pressure was 120 lb. per sq. in., exhaust pressure 20 lb., compression pressure 40 lb. and m.e.p. 35 lb.

In subsequent types of the same engine, the compression pressure was increased with consequent increase in thermal efficiency.

This is shown in Figs. 3 and 4, which are diagrams from 1893 and 1905 types Hornsby-Akroyd engines respectively. Fig. 3 represents an 8.02-in. by 14-in. engine developing 5 b.h.p. at 214 r.p.m.; initial pressure 120 lb. per sq. in., exhaust pressure 22 lb., compression pressure 46 lb., m.e.p. 37.5 lb.; heating value of fuel 18,600 B.t.u., specific gravity 0.824, fuel consumption 0.99 lb. per b.h.p-hr. Thermal efficiency 13.8 per cent.

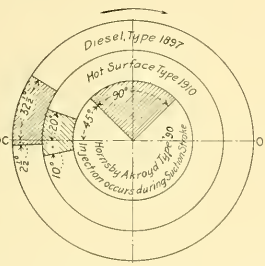



Fig. 9 Periods of Injection of Fuel

Fig. 4 is taken from an engine with cylinder diameter 14.5 in. and stroke 17 in.; r.p.m. 202; initial pressure 168 lb. per sq. in., exhaust pressure 30 lb., compression pressure 60 lb., and m.e.p. 48 lb. B.h.p. 27. Heating value of fuel 19,000 B.t.u., specific gravity 0.825. Fuel consumption 0.74 lb. per b.h.p-hr. Thermal efficiency 18 per cent.

Fig. 5 is taken from a De La Vergne oil engine, type DH, built in 1913. Cylinder diameter 14 in., stroke 24 in. Initial pressure 325 lb. per sq. in., exhaust pressure 25 lb., compression pressure 169 lb. and m.e.p. 75 lb. Heating value of fuel 18,500 B.t.u., and fuel consumption 0.543 lb. per b.h.p-hr. Brake horsepower 60 at 210 r.p.m. Thermal efficiency 25 per cent.

Fig. 6 is a diagram from a Ruston Proctor engine, type 1913. Initial pressure 550 lb. per sq. in. approximately, exhaust pressure 25 lb., compression pressure 280 lb. and m.e.p. 70 lb. Heating value of fuel 19,000 B.t.u. Fuel consumption 0.46 lb. per b.h.p-hr. Thermal efficiency 29 per cent.

A diagram from a De La Vergne engine, type FH, 1915, is shown in Fig. 7. Cylinder diameter of this engine 17 in. and stroke 27½ in. Initial pressure 475 lb. per sq. in., exhaust pressure 30 lb., compression pressure 260 lb. and m.e.p. 82 lb. Engine develops 100 b.h.p. at 200 r.p.m. Fuel consumption 0.450 lb. per b.h.p-hr. of California crude oil, having a heating value of 18,500 B.t.u. Thermal efficiency 30.5 per cent.

Fig. 8 is taken from a Diesel engine, type 1915, cylinder diameter 18.875 in. and stroke 28.375 in. Initial pressure 550 lb. sq. in., exhaust pressure 40 lb., compression pressure 550 lb. and m.e.p. 95 lb. Heating value of fuel 19,266 B.t.u., and fuel consumption 0.407 lb. per b.h.p-hr. Thermal efficiency 32.5 per cent.

It will be noted from these diagrams that the thermal efficiency, 12.8 per cent in 1888, has through improvement

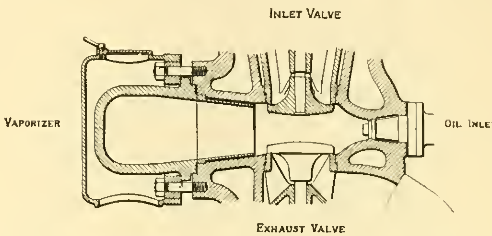



Fig. 10 Cross-Section of Combustion Space of De La Vergne Oil Engine

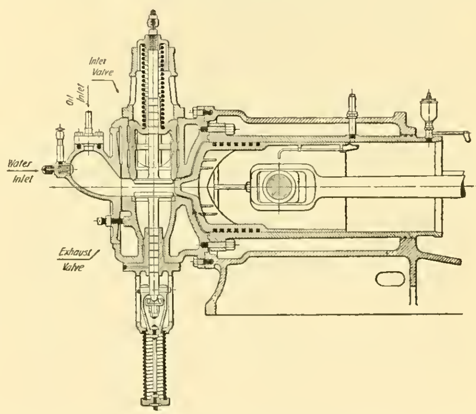



Fig. 11 Section of Ruston Proctor Oil Engine Cylinder

in design and by increased compression pressures in the later engines been increased to 30.5 per cent in the hot-surface type of oil engine. In the Diesel type it is now 32.5 per cent. All calculations are on the basis of brake or actual horsepower and not indicated horsepower.

### TYPES OF ENGINES

Previous to about 1892 all oil engines were of either the hot surface or electric ignition type, with the fuel injected during either the first outward stroke of the piston or air inlet period of the cycle. In Fig. 9 are shown the periods of injection in the different types referred to.

A description of the Diesel system was first published about 1892. In the Diesel cycle the fuel injection period did not take place until compression was completed, or nearly so, and the compression pressure was carried to a point where a temperature sufficient to cause ignition was obtained. High

pressure (about 1000 lb.) air was injected with the fuel, thoroughly atomizing or pulverizing it, and thus sufficient pressure to overcome that existing in the combustion space at the time of injection was obtained. This system gave in 1892 the highest thermal efficiency, as it does today.

Realizing that moderate sized oil engines of from about 75 h.p. to about 400 h.p. and a thermal efficiency somewhat less than that attained in the Diesel type and with lower range of pressures could be produced with some advantages and at less expense, various manufacturers in Europe and in this country have built so-called semi-Diesel or hot-surface type engines, embodying the Diesel method of fuel injection, but in some cases without the air blast.

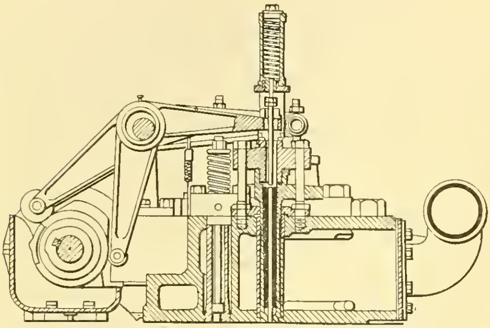


Fig. 12 Section of Willans-Robinson Cylinder Head

Regardless of their cycles of operations, at the present time oil engines may be divided into two classes: *Diesel* and *hot-surface type* or *semi-Diesel*. With the exception of the engine shown in Fig. 16, all engines here illustrated are of the 4-cycle type. The majority of manufacturers in Europe and in this country are building 4-cycle types for stationary and marine purposes. With its comparative simplicity, the 2-cycle engine may have decided advantages in the smaller sizes. In the larger sizes the advantage for stationary service is reduced cost of manufacture, while for marine service, reduced weight and space occupied is also claimed by the advocates of the 2-cycle type. From cylinders of the same dimensions the power is about 70 per cent greater and the fuel consumption is regarded as approximately 10 per cent greater. Accumulated heat in cylinder head and other parts surrounding the combustion space and main crankshaft bearing troubles have, however, given some European builders considerable difficulty with the 2-cycle type in the larger sizes.

TABLE I OPERATION OF FOUR OIL ENGINES DURING 1914

| Engine No. | Desired period of operation, hr. | Actual period of operation, hr. | Per cent of desired period |
|---|---|---|---|
| 1 | 6803.80 | 6684.54 | 98.25 |
| 2 (spare unit) | ....... | 700.47 | ..... |
| 3 | 8556.75 | 8411.55 | 98.30 |
| 4 | 8626 | 8457.47 | 98.05 |

Figs. 19 and 20 show the combustion space, the fuel inlet and the arrangement of air inlet and exhaust valves of representative Diesel engines.

Fig. 10 is a section of the combustion space of the hot-surface type engine where the fuel and high-pressure air are not injected into the combustion space, as in Figs. 19 and 20, but are first forced into a vaporizing chamber which is heated before starting and in which the temperature is maintained by the combustion of the fuel in it.

The combustion space of another hot-surface type engine in which somewhat of the same system of operation as in the previous engine obtains is illustrated in Fig. 11,[1] but here the air is not injected with the fuel as in the engine in Fig. 10, but a mechanical sprayer or pulverizer is used and a slight amount of water is also allowed to enter the chamber in addition to the fuel.

## DESIGN

The general construction of both Diesel and hot-surface types of engines is shown in the different illustrations. Examination of the different details of construction of the very large number of Diesel and other oil engines built in different countries of the world shows many interesting designs.

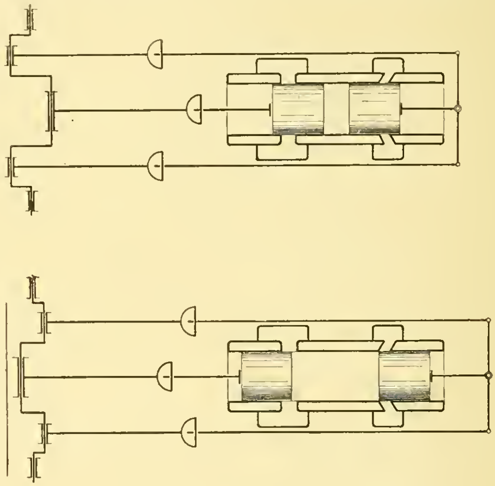


Fig. 13 Arrangement of Junkers Oil Engine

It would not be feasible here to refer to all the different details of construction. Important elements of large modern oil engines are:

*a* Cylinder heads,

*b* Trunk piston *or* crosshead and shorter piston,

*c* Sprayer or pulverizer.

*Cylinder Head.* Considerable difficulty was in the past experienced with the cylinder heads of Diesel as well as of hot-surface type engines due to fracture largely attributable to high temperatures and pressures obtaining in the combustion space. In recent years this difficulty has been largely or entirely overcome. In some cases the reason for this trouble was improper casting, the cores shifting and causing unequal thicknesses of the walls of the cylinder head. Amended and improved design in modern engines has, in most types, eliminated this trouble. The heads are now made of such

[1] Shown by permission of Messrs. Illiffe & Co., London, Eng.

design and material that uniform thickness of the walls is obtained, and the material (soft charcoal iron or its equivalent) is such as to allow easy and uniform expansion and contraction.

Various designs of cylinder heads, among which the following are of interest, have been made to simplify the castings: Fig. 12[1] shows the cylinder head of the engine made by Willans-Robinson, Rugby, England, and by the Dow Steam Pump Co. in California. This is a notable design and with it the strains due to contraction in the foundry are reduced. In this cylinder head recesses are only made for the insertion of the air inlet and exhaust valves. The fuel inlet valve is inserted in a tube which has different diameters at its ends and which is pressed into place between the lower and upper facings of the walls of the cylinder head. The starting air valve is similarly inserted in a separate tube. No recess is cored in the cylinder head for these valves and in this way the shape of the castings is simplified and unequal masses of metal are eliminated.

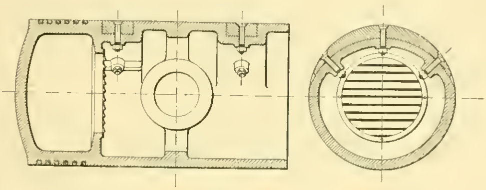


Fig. 14 Section of M. A. N. Piston

A part section of the Junkers type of Diesel engine in which the cylinder head is eliminated entirely is shown in Fig. 13. This engine is equipped with two pistons in each cylinder, that farther from the crankshaft moving in the opposite direction to that nearer the crankshaft and both being connected by suitable crosshead and connecting rods to the outside cranks at 180 deg. from the main crank. In this type, the fuel is injected into the combustion space formed between the two pistons.

*Piston and Crosshead.* The trunk piston without crosshead is shown in Figs. 19 and 20. In 4-cycle, single-acting engines developing over 150 h.p. in one cylinder a crosshead is recommended. The advantages of the crosshead type may thus be stated:

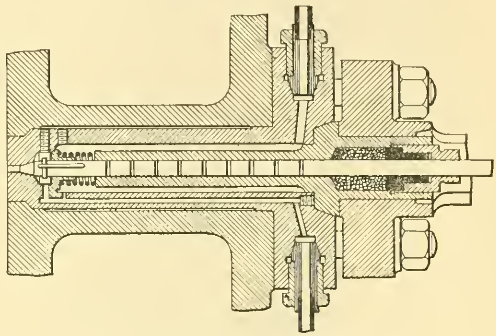


Fig. 15 Section of Sabathe Sprayer

(1) The guides in which the crosshead moves are maintained at an even temperature and are not subject to the expansion and contraction of the cylinder that they are with the trunk piston.

(2) It is simpler to lubricate the crosshead pin than the trunk piston pin, as the former does not come in contact with the heated parts of the engine.

[1] Figs. 12, 15, 19 and 20 are reproduced by special permission of Messrs. Spon and Chamberlain, publishers of "Marine and Stationary Diesel Engines," by the author (in press).

TABLE 2 POWER GENERATION COSTS FOR 1914

| Estimated output | | Oil consumed | | | | Cost of operation, dollars | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Lb. per | | Labor | | Materials and supplies | | | | | |
| At switchboard kw-hr. | At engines h.p-hr. | Gal. | Lb. | Kw-hr. switch-board | H.p-hr. engines | Operat-ing | Main-tenance | Fuel oil 16½c. gal. | Lubricating oil 71c. per 1000 h.p-hr. | Repair parts | Belts | Misc. supplies | Total cost dollars |
| 2,469,293 | 3,996,196 | 278,595 | 2,061,602 | 0 84 | 0 52 | 7907.31 | 2211.76 | 46603.62 | 2838 82 | 1659.50 | 792.92 | 1044 64 | 63058.57 |
| Per kw-hr...... | .... | 0.113 | 0.835 | ... | .... | 0.0032 | 0.0009 | 0.0188 | 0.0011 | 0.0007 | 0.0008 | .... | 0.0255 |
| Per h.p-hr.... | .... | 0.083 | 0.516 | ... | .... | 0.0020 | 0 0006 | 0.0116 | 0.0007 | 0.0004 | 0.0005 | .. | 0.0158 |
| | | | | | | | | Fuel oil 2 1/7c. gal. | Lubricating oil 35c. per 1000 h.p-hr. | | | | |
| . | ... | ... | ... | ... | .... | .... | .... | 5969.29 | 1400.00 | .... | .... | ... | 20985.42 |
| Per kw-hr... | ... | .. | ... | .. | ... | .... | .... | 0.0024 | 0.00057 | .... | .... | ... | 0.0086 |
| Per h.p-hr... | .... | . | .. | | .. | .... | .... | 0 0015 | 0.00035 | .... | .. | ... | 0.0053 |

Based on 8640 hr. per year, that is with fuel at 16 5c. per gallon and lubricating oil 71c. per 1000 h.p-hr. equivalent to: $136.51 per h.p. year at the engines; 164 41 per kw. year at the switchboard

Or with fuel oil at 2 1/7c. per gallon and lubricant at 35c. per 1000 h.p. hours equivalent to: $45.70 per h.p. year at the engines; 74.50 per kw. year at the switchboard

The last named figures are given showing costs under ordinary conditions. Allowance must be made for increased cost of materials and supplies due to excessive charge for transportation.

(3) The guides of the crosshead type can be more easily adjusted, whereas the ordinary trunk piston does not allow of adjustment.

Advocates of the trunk piston in preference to the crosshead type point out that the wear in the cylinder is due to the piston rings and not to the friction of the trunk piston, that in a well designed engine the pressure of the piston on the cylinder walls is so slight, its proper lubrication can easily be maintained and that the crosshead type requires more space and is more expensive to manufacture.

Fig. 14 shows the type of piston made by the M. A. N. in Germany. This is equipped with loose strips on its upper surface which permit adjustment to take up the wear on the piston. The makers of this type claim for it the advantages of a crosshead without the disadvantages of greater cost of manufacture and the occupation of more space.

*Sprayer or Pulverizer.* A most important feature of all oil engines is the sprayer or pulverizer through which the fuel and high-pressure air are injected into the combustion space. Its function is to thoroughly atomize the fuel and mix the particles with the air before the latter enters or as it enters the combustion space.

Where a heavy crude oil or tar is the fuel, a slight amount of lighter fuel is used in addition. The sprayer is then equipped with two openings and passages properly arranged so that the lighter fuel enters the combustion space and ignites before the heavier fuel enters. The temperature is raised and the ignition of the heavier fuel is facilitated. Separate fuel pumps are used for each fuel.

An interesting fuel inlet valve is that used by the Société des Moteurs Sabathé with their engine for submarine use; this valve is shown in section in Fig. 15. It is equipped with

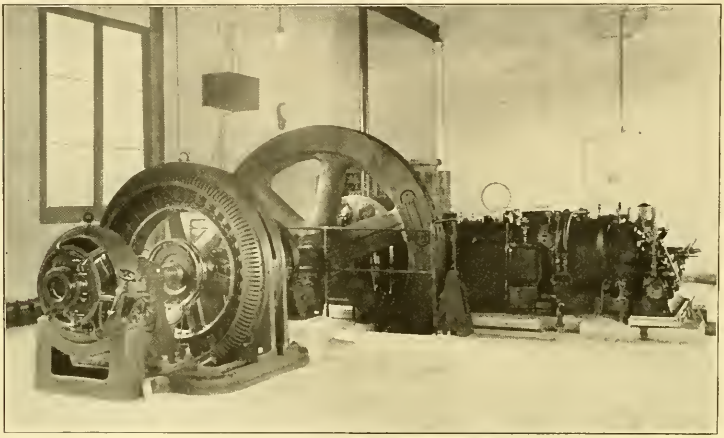


Fig. 16 250-h.p. 2-Cycle Snow Oil Engine

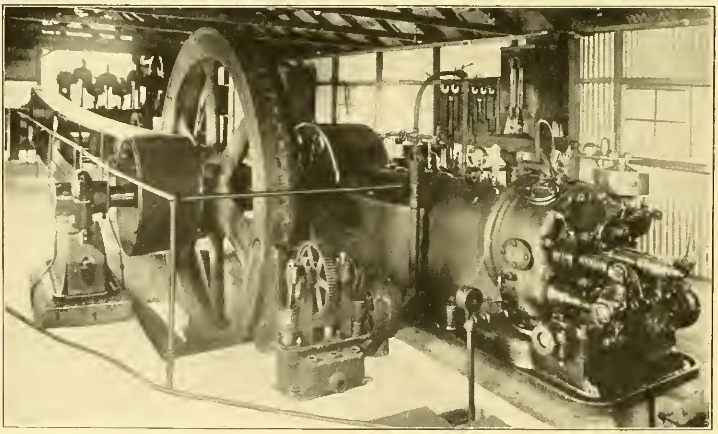


Fig. 17 60-h.p. 4-Cycle Snow Oil Engine

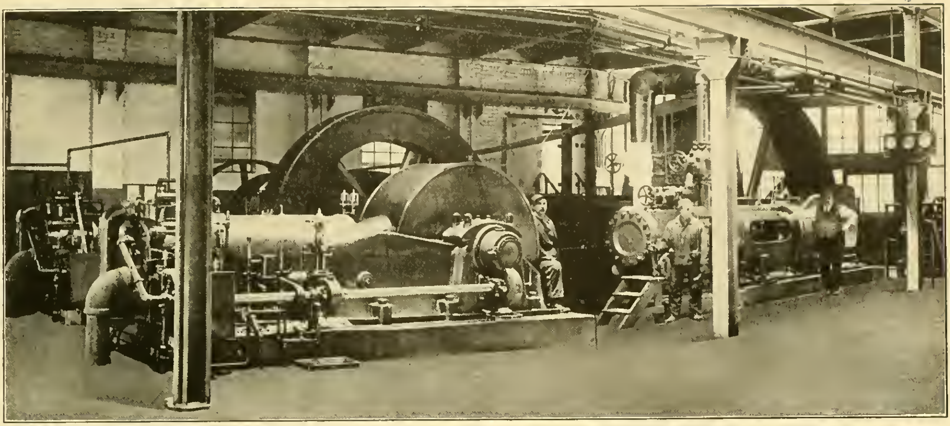


Fig. 18 De La Vergne Oil Engine at Oakland, Cal.

two valves, one of which is the ordinary type of fuel inlet valve and the second is larger in diameter and loose on the former, being held in place by the spring as shown. This fuel inlet arrangement is designed to effect "mixed combustion" by allowing two periods of fuel injection. Its principle is as follows: The fuel injection from the first valve is arranged to enter the combustion space when the compression is about 450 lb. and the volume is constant, with the result that the pressure instantly rises. Immediately afterwards the injection of fuel from the upper passage hitherto held in check

TABLE 3 COMPARISON OF DIESEL MOTOR SHIP AND STEAMSHIP

| | Steamship "Kina" (Single screw) | Motor ship "Siam" (Twin screw) |
|---|---|---|
| Length between perpendiculars, ft. | 385 | 410 |
| Breadth, ft. | 53 | 55 |
| Depth moulded | 26 ft, $10\frac{3}{4}$ in. | 30 ft, 6 in. |
| Cargo, tons | 7673 | 8670 |
| Distance covered, miles | 27808 | 27818 |
| Fuel, tons | 4858.6, coal | 1120.2, oil |
| Cost of fuel, dollars | 5.25 (22 sh) | 7.25 (35 sh) oil |
| Fuel cost, dollars, 1000 tons cargo 1 mile at 11 knots | 13.6 (6.08 d) | 4.0 (2 d) |
| Fuel cost, dollars, 8500 tons 27.818 miles at 11 knots | 28.702 | 9.400 |
| Saving in favor of motor ship, dollars | 19.302 | |

Circuit of Europe, East Asia and return.
Extract from paper read by Mr. I. Knudsen, Malmo, Sweden, July, 1914.

by the larger valve is allowed to slowly enter the combustion space while the volume is increasing. The movement of the valves is, of course, mechanically controlled and the timing of injection can be altered to suit the requirements of varying speeds. Economy of injection air as well as greater efficiency is claimed for this type.

### RELIABILITY AND ECONOMY

One of the most important questions of the operation of oil engines and one frequently discussed and referred to by those who are not fully informed on the subject, or who are seeking information, is in regard to reliability of operation. The most forcible reply is that many oil engines have operated in different installations, some for three months, some for six and others for eight months continuously, day and night without stoppage, and with different crude oils.

Table 1 is taken from the records of a mining plant in

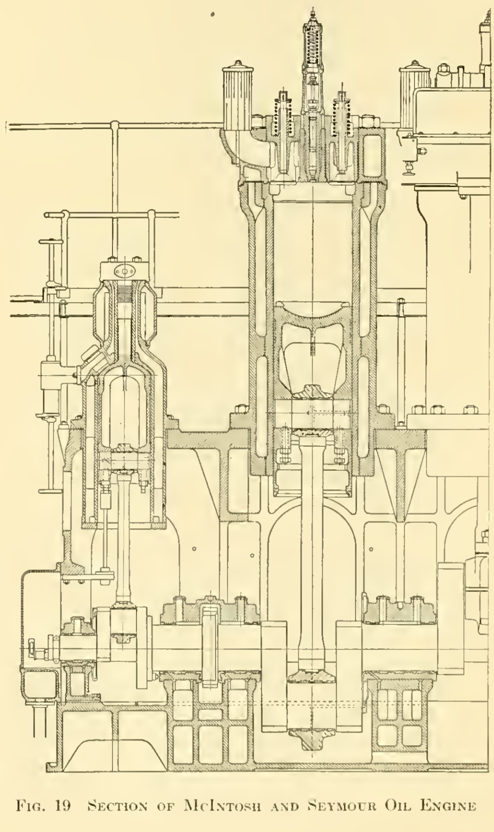


Fig. 19 Section of McIntosh and Seymour Oil Engine

TABLE 4 COMPARISON OF ENGINE FUELS

| Maker | Union Oil Co. | Union Oil Co. | Std. Oil Co. | Std. Oil Co. | Union Oil Co. | General Petroleum Co. National Petroleum Co. | | |
|---|---|---|---|---|---|---|---|---|
| Trade name | California crude | Diesel oil | Calol fuel oil | Star fuel oil | Stove oil | Kellogs stove dist. hvy. slush tops | Kellogs No. 2 tops dist. | No. 1 water white dist. |
| Gravity at 60 deg. in deg. Beaumé.............. | 14–18 | 23.5–24 | 24 | 27.2 | 28 | 36–40 | 43–45 | 48–51 |
| Flashpoint (Abel-Pentsky) burning pt. closed cup deg. fahr.............. | 150–175 | 175–185 | 150 | 190 | 175 | 100 | 50 | 25–30 |
| | 175–225 | ...... | ...... | 225 | 210 | 125 | 65–75 | 40–50 |
| Flashpoint open cup burning pt., deg. fahr....... | ...... | 195–205 | ...... | 210 | 200 | 120 | 63 | 30–35 |
| | ...... | 235–245 | ...... | 243 | 225 | 140 | 72 | 50–60 |
| B.t.u. per lb............. | 18,500 | 18,950–19,250 | 19,000 | 19,200 | 19,300 | 18,000–19,000 | 18,000–19,000 | 18,000–19,000 |
| Sulphur, per cent........ | usually under 1 | 0.75 | 0 75 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| Asphalt, per cent........ | 50 | 20 | 25 | 20 | 10–20 | 0.10 | 0.05 | 0.001 |
| Water, per cent.......... | usually under 2 | 0.5 | ...... | 0.08 | Trace | Trace | None | None |
| Residue................. | ...... | ...... | ...... | at 300 deg fahr. 3 per cent | ...... | ...... | at 500 deg. fahr. less than 1 per cent | ...... |

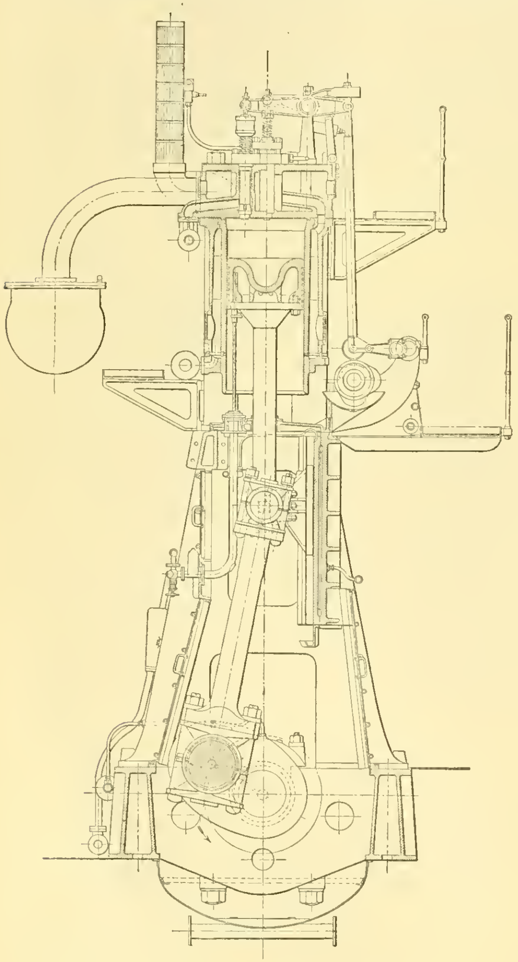


FIG. 20 SECTION OF BURMEISTER AND WAIN OIL ENGINE

Arizona which is operating continuously 24 hr. per day. This plant is equipped with four hot-surface type engines, two of 180 b.h.p., one 250 b.h.p. and one 280 b.h.p., belted to shafting or direct connected to electric generators. The engines are installed at an altitude of about 7000 ft.; they are 90 miles from a railroad station and oil fuel and supplies have to be hauled this distance over mountain roads. The cost of hauling is approximately one cent a pound, which accounts for the high cost of fuel, viz: 16.5 cents per gallon. The engines operate on fuel oil of 22-deg. Beaumé. Table 2 shows power generation costs of the same installation for the year 1914.

The advantage of the oil engine for operating almost any class of machinery in comparison with other prime movers is conceded, but for its economy to be fully realized the load factor should be as high as possible.

## EXAMPLES OF ENGINES

Fig. 16 shows a 250-h.p. twin-cylinder 2-cycle Snow Diesel horizontal oil engine, direct connected by flexible coupling to a 60-cycle alternator and operating with California and Mexican crude oils; this engine has been in operation about six months. Fig. 17 shows a 60-h.p. single cylinder 4-cycle horizontal Diesel engine by the same maker, operating with 18-deg. Beaumé California crude oil and driving by belt a deep well pump. This plant has been running about four months.

In Fig. 18 is shown a 280-h.p. type FH De La Vergne oil engine operating an ice machine and electric generator by belt and using California crude oil, 14-deg. Beaumé. This installation is at Oakland, Cal., and has been in operation for about one year. The manufacturers of this engine guarantee it to operate on any fuel or crude oil produced in the United States and Mexico having 18,000 B.t.u. and not more than 1 per cent water. This engine has operated for 800 hr. continuously without stopping. Between Nov. 23, 1914, and July 23, 1915, the plant was in operation 5400 hr. during which period 12,330 tons of ice were manufactured.

Fig. 19 shows a partial sectional view of the McIntosh-Seymour enclosed type vertical 4-cycle 4-cylinder single acting stationary Diesel engine of 500 h.p., with 2-stage air compressor for furnishing high pressure injection air placed in line with the motor cylinders and operated, as is now standard practice, from an overhung crank on the main crankshaft.

This drawing shows one of the most recently developed Diesel vertical engines in this country. The details of design, such as cooling, pulverizing of the fuel, valve motion, etc., have had careful attention. While the illustration shows the enclosed crank case type of engine, the latter is also made with " A " frame construction.

The Burmeister and Wain Diesel marine 4-cycle single acting type engine built by this firm in Copenhagen, Denmark, and installed in the latest motor ships made by them is shown in Fig. 20. Each engine has six cylinders, 29 9/64-in. diameter and 43 5/16-in. stroke, and develops 2000 i.h.p. at 100 r.p.m. The engines are reversible by longitudinal movement of the camshaft in the regular way.

There are many interesting features in this engine, notably the spray valve which has two coned surfaces, one forming the valve seat and the other spreading the spray. It opens outward towards the piston, instead of inwards as in most types; in this way the spray of fuel is very evenly distributed throughout the whole of the combustion space and the heat evolved during combustion is distributed over the whole area of the piston. The process of starting and maneuvering is simplified by the starting valve which is automatically operated by the pressure of the air and only requires the opening of one valve. In this type of engine the camshaft is operated from the crankshaft by a chain of spur gears, which system has replaced the vertical intermediate shaft and gearing previously used.

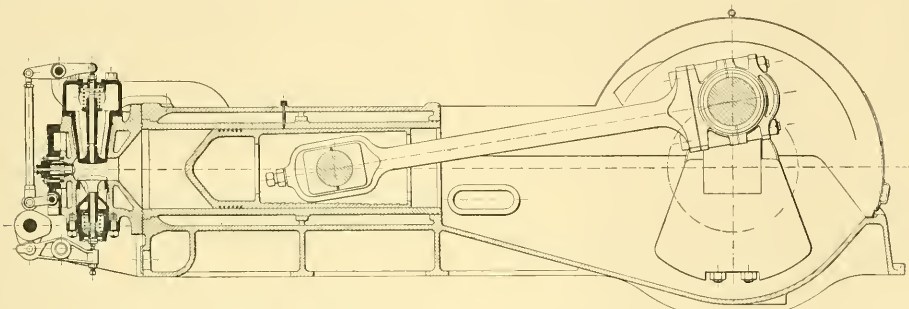


Fig. 21 Section of De La Vergne Oil Engine

This design is considered one of the most successful marine engines in large sizes and several motor ships equipped with it have made long voyages. In a paper by I. Knudsen, read in July, 1914, at Malmo, Sweden, the figures in Table 3 showing particulars of a long voyage of one of these motor ships in comparison with a steamship of the same dimensions were given.

TABLE 5 COST OF ENGINE OPERATION

| Size of unit | Type of engine | b.h.p. per gal. fuel | Fuel cost per gal. Cents | First cost per b.h.p. Dollars | Total first cost Dollars | Yearly fixed 20 per cent charge, Dollars | Fuel cost 24 hr. per day for 100 150 200 250 days Dollars | | | | Total yearly charge, fuel plus fixed charges 100 150 200 250 days Dollars | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 100 | 150 | 200 | 250 | 100 | 150 | 200 | 250 |
| 50 h.p. | Distillates | 10 | 5 | 25 | 1250 | 250 | 600 | 900 | 1200 | 1500 | 850 | 1150 | 1450 | 1750 |
| | Tops distillates | 10 | 2 3/4 | 25 | 1250 | 250 | 330 | 495 | 660 | 825 | 580 | 745 | 910 | 1075 |
| | Semi-Diesel | 10 | 2 1/7 | 60 | 3000 | 600 | 257 | 385 | 514 | 624 | 857 | 985 | 1114 | 1242 |
| | Diesel | 16 | 2 1/7 | 75 | 3750 | 750 | 160 | 241 | 321 | 401 | 910 | 991 | 1071 | 1151 |
| 100 h.p. | Distillate | 10 | 5 | 30 | 3000 | 600 | 1200 | 1800 | 2400 | 3000 | 1800 | 2400 | 3000 | 3600 |
| | Tops | 10 | 2 3/4 | 30 | 3000 | 600 | 660 | 990 | 1320 | 1650 | 1260 | 1590 | 1920 | 2250 |
| | Semi-Diesel | 10 | 2 1/7 | 55 | 5500 | 1100 | 514 | 770 | 1028 | 1284 | 1614 | 1870 | 2128 | 2384 |
| | Hot surface-high economy | 16 | 2 1/7 | 65 | 6500 | 1300 | 320 | 482 | 642 | 802 | 1620 | 1782 | 1942 | 2142 |
| | Diesel | 16 | 2 1/7 | 75 | 7500 | 1500 | 320 | 482 | 642 | 802 | 1820 | 1982 | 2142 | 2302 |
| 150 h.p. | Distillate | 10 | 5 | 30 | 4500 | 900 | 1800 | 2700 | 3600 | 4500 | 2700 | 3600 | 4500 | 5400 |
| | Tops | 10 | 2 3/4 | 30 | 4500 | 900 | 990 | 1485 | 1980 | 2475 | 1890 | 2385 | 2880 | 3375 |
| | Semi-Diesel | 10 | 2 1/7 | 50 | 7500 | 1500 | 771 | 1155 | 1542 | 1926 | 2271 | 2655 | 3042 | 3426 |
| | Hot surface-high economy | 16 | 2 1/7 | 65 | 9750 | 1950 | 480 | 723 | 962 | 1203 | 2430 | 2673 | 2912 | 3153 |
| | Diesel | 16 | 2 1/7 | 70 | 10500 | 2100 | 480 | 723 | 962 | 1203 | 2580 | 2823 | 3062 | 3303 |
| 250 h.p. | Distillate | 10 | 5 | 30 | 7500 | 1500 | 3000 | 4500 | 6000 | 7500 | 4500 | 6000 | 7500 | 9000 |
| | Tops | 10 | 2 3/4 | 30 | 7500 | 1500 | 1650 | 2475 | 3300 | 4125 | 3150 | 3975 | 4800 | 5625 |
| | Semi-Diesel | 10 | 2 1/7 | 50 | 12500 | 2560 | 1285 | 1925 | 2570 | 3210 | 3785 | 4425 | 5070 | 5710 |
| | Hot surface-high economy | 16 | 2 1/7 | 60 | 15000 | 3000 | 800 | 1202 | 1605 | 2005 | 3800 | 4202 | 4605 | 5005 |
| | Diesel | 16 | 2 1/7 | 65 | 16250 | 3250 | 800 | 1202 | 1605 | 2005 | 4050 | 4452 | 4854 | 5255 |

Yearly fixed charge is arrived at as follows: interest, 6 per cent; taxes and insurance, 1 per cent; repairs, 3 per cent; depreciation, 10 per cent.

Engine using distillate 48–51 deg. B. oil has a thermal efficiency of 20 per cent under full load.
Engine using tops distillate 38–42 deg. B. oil has a thermal efficiency of 20 per cent under full load.
Semi-Diesel engine using 24–28 deg. B. oil has a thermal efficiency of 18 per cent under full load.
Hot surface high economy engine using 16 deg. B. oil has a thermal efficiency of 27 per cent under full load.
Diesel engine using 18 deg. B. oil has a thermal efficiency of 28.4 per cent under full load.

## OIL ENGINES IN PIPE LINE SERVICE

Fig. 21 shows a sectional view of the latest design of De La Vergne 150-h.p. single and 300-h.p. twin-cylinder oil engine. In this construction the valve motion consists of the camshaft geared to the crankshaft in the ordinary way, but this intermediate shaft actuates a second shaft placed behind the cylinder head and operating parallel to the crankshaft. The air and the exhaust valves are so arranged that they can be easily removed and the piston is made of greater length so as to reduce the pressure and minimize the amount of wear between it and the cylinder walls. Details of lubrication of all bearings and other moving parts have been improved. The piston pin is lubricated through the hollow connecting rod.

In 1902, the writer arranged and introduced the oil engine for oil pipe line pumping service. A number of engines for this service were first installed for the Gulf Pipe Line Company in Texas and since then the installation of several hundred engines with many of the leading pipe line companies in the south or southwest territories has followed. These pumping stations consist of several units, some stations

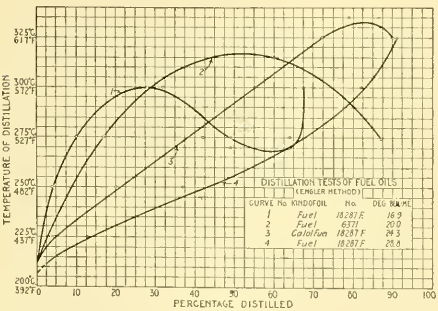



Fig. 22 Curves showing Distillation Tests of Fuels

having as many as six engines. The capacity of each unit varies from 90 to 150 h.p. and is composed of the engine direct connected to a vertical or horizontal power pump. The former installations were equipped with friction clutch couplings between the engines and the pumps. In the later installations the connection used between engines and pumps is a flexible coupling or, in some cases, a rigid coupling. The pump is furnished with a by-pass between the suction and discharge so that, in starting the engine, the load is very much reduced. In the latest arrangement of this pumping unit the oil engine flywheel is placed close to the out-board bearing. In this way the main bearings are relieved of this weight and unequal wear on the bearings is avoided.

This type of pumping outfit was fully described in a paper[1] before the Society by Forrest M. Towl, where it was stated the total efficiency of an 85-h.p. engine in three tests was 26.8, 27.75 and 27.52 per cent, respectively. The efficiency of pump and transmission was stated as 92.1 per cent. The fuel consumption per pump horsepower by displacement was 0.5171 lb. Tests were made with 33-deg. Beaumé fuel having a heat value of 19,059 B.t.u. per pound.

[1] Trans. A. S. M. E., vol. 33, page 905.

## CALIFORNIA FUELS

The oil engine for pipe line service has not yet been used to any extent in the California oil fields. Table 4[1] shows the characteristics of California crude oils, while Fig. 22 gives results of distillation tests. It is necessary to heat such to a temperature that they will flow readily in the pipe lines and can be satisfactorily handled by the pump. The amount of heat necessary to raise the temperature of crude oil of 15-deg. Beaumé, assuming its specific heat to be 0.333 (which value seems to be difficult to exactly determine), is shown by the following remarks:

The amount of oil pumped per b.h.p-hr. at a pressure of 570 lb. is 135 gal., and the heat required to raise this quantity of oil through a range of 41 deg., or from a temperature of 69 deg. to 110 deg. fahr., would be 18,400 B.t.u. The amount of waste heat from an oil engine consuming half a pound of fuel per actual h.p-hr., both from the waste heat of the water jacket and that recoverable from the exhaust, with the most advantageous arrangement, is approximately 4200 B.t.u. Thus, taking this waste heat, it is evident that 14,200 B.t.u. per b.h.p. of the pumping outfit per hour would have to be furnished from an outside source to provide sufficient heat to raise the oil to the required temperature.

In a steam pumping plant this can be advantageously taken from the exhaust steam of the steam plant. The fuel consumption of the average steam pumping plant may be taken as 1.5 lb. of oil fuel per b.h.p-hr., but sufficient heat is in this case also available for heating the crude oil to the temperature above referred to.

With the oil engine plant, 0.5 lb. of fuel per b.h.p-hr. is required for the actual pumping process and from the figures above it will be seen that an amount of heating equivalent to that developed from a pound of oil would be necessary to heat the oil passing through the pipe line. Thus the total fuel consumption of the oil engine and that of the steam pump, allowing for heating, is approximately the same.

The oil engine outfit can operate with a poor quality of cooling water which would, however, be unsatisfactory for boiler use. This is a great advantage in favor of the former in many localities where only a poor quality of water can be procured.

Table 5[2] shows the costs of installation and operation of the different types of engines specified prevailing in California in 1914. The prices quoted for each fuel may not now be correct and the costs of fuel may require slight modification to conform with prevailing prices. The writer is informed that the price for 48 to 50-deg. Beaumé distillate is 6 cents per gal. in 110-gal. drums, while Diesel fuel oil is quoted at 85 cents per 42-gal. barrel in tank cars 25 miles north of San Francisco. Calol fuel oil 24-deg. Beaumé is 75 cents per 42 gal. and fuel oil not less than 14-deg. Beaumé is 60 cents per barrel in tank cars f.o.b. Richmond, Cal. The yearly fixed charge of 20 per cent is a higher rate than is usual to allow in the Eastern States where 5 per cent interest and 5 per cent depreciation are considered sufficient.

[1] Table 4 was partly compiled by Smith-Booth-Usher Co. and its insertion is due to their courtesy. Fig. 23 is shown by permission of the Standard Oil Co. of California.

[2] Table 5 was compiled by Messrs. Smith-Booth-Usher Co. in 1914. It is due to their courtesy that it is shown. Data regarding hot surface engine has been added.

# THE STRENGTH OF GEAR TEETH

BY GUIDO H. MARX AND LAWRENCE E. CUTTER,

PALO ALTO, CAL.

Members of the Society

(SECOND PAPER)

THE investigations reported upon in this paper were undertaken for the purpose of supplementing those presented to the Society at its Annual Meeting of 1912, by the senior author.[1] The methods of conducting the tests, and of mathematical analysis employed in working up the results, were substantially the same as described in the earlier paper and are not repeated here. Paragraph references to the first paper will be used to direct attention to explanatory matter which is here omitted.

The limitations of the apparatus available for the earlier experiments made it impossible to secure positive data at pitch speeds exceeding 500 ft. per min., although significant data of a negative character were obtained at speeds up to 1000 ft. per min.[2]

In order to get positive data at high pitch speeds, an improved form of the apparatus used in the earlier experiments was devised[3] and connected by chain drive to a 50-h.p. motor capable of taking care of momentary overloads of 100 per cent. The main difference between the new apparatus and the old lay in the employment of Hess-Bright ball-bearings throughout in place of ordinary journal bearings. Each shaft was carried on two of these radial bearings, No. 307.

A second improvement was in the prony brake (Fig. 1). This was devised to be self-contained, the friction load due to scooping up the circulating cooling water being weighed on the scales with the rest of the friction load. It worked with great steadiness and proved eminently satisfactory. Owing to the high rim speeds reached, the brake wheel was carefully finished all over and had a web in place of arms.

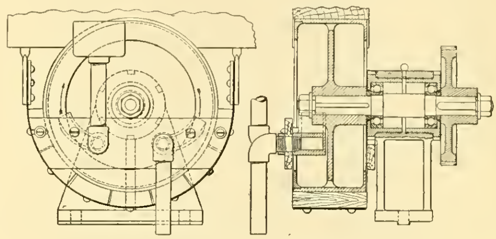


FIG. 1 PRONY BRAKE

A few holes drilled through the web at its outer circumference permitted the free circulation of the cooling water.

### OUTLINE OF TESTS

The gears which were tested were made by The Brown & Sharpe Mfg. Co. and the Fellows Gear Shaper Co. The in-

[1] Trans. A. S. M. E., vol. 34, paper 1382, pp. 1323-1398.
[2] Trans. A.S.M.E., vol. 34, p. 1390.
[3] Par. 8 and 9, paper 1382.

## ABSTRACT OF PREVIOUS PAPER ON THE STRENGTH OF GEAR TEETH, By GUIDO H. MARX

The teeth of gear wheels when transmitting power are individually subjected to an action akin to that applied to a beam fixed at one end, with a load somewhere between the fixed and the free ends. All standard formulae or diagrams for the proportioning of such teeth therefor involve a factor representing the allowable unit fiber stress in a cantilever beam subjected to a bending moment.

The experiments described in this paper were undertaken with the primary purpose of throwing some light upon the question of this allowable unit fiber stress for modern cut cast-iron gear teeth under operating conditions, since definite data upon this point have been lacking, particularly with reference to the effect of pitch line velocity.

The formula for the safe equivalent load at pitch line as derived from these experiments is:

$$W = \frac{spf}{k}\left(0.154 - \frac{1.26}{n}\right) va$$

in which

$W$ = safe working load at pitch line in lb.
$s$ = modulus of rupture = 39,000 in these tests, but ordinarily to be taken = 36,000
$p$ = circular pitch in in.
$f$ = width of face in in.
$k$ = factor of safety
$n$ = number of teeth in gear
$v$ = velocity coefficient from take below
$a$ = arc of action cofficient from table below

[1] Trans. A. S. M. E., vol. 34, paper 1382, pp. 1323-1398.

COEFFICIENTS BASED ON ARC OF ACTION

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ratio: Arc of Action / Pitch Arc | 1 | 1.4 | 1.6 | 1.7 | 1.8 | 1.9 | 1.95 | 2.00 |
| Corresponding $a$..... | 1 | 1.05 | 1.1 | 1.15 | 1.24 | 1.38 | 1.47 | 1.60 |

VELOCITY COEFFICIENTS

| Pitch velocity, ft. per min.... | 000 | 100 | 150 | 200 | 300 | 400 | 500 |
|---|---|---|---|---|---|---|---|
| Ratio: Breaking Load at Given Vel. / Breaking Load at Zero Vel. (20-tooth pinions) | 1.0 | 0.789 | 0.725 | 0.702 | 0.702 | 0.707 | 0.712 |
| Ratio: Breaking Load at Given Vel. / Breaking Load at Zero Vel. (30- and 40-tooth gears) | 1.0 | 0.819 | 0.792 | 0.768 | 0.726 | 0.743 | 0.770 |
| v—Velocity coefficient, safe........ | 1.0 | 0.80 | 0.75 | 0.72 | 0.70 | 0.68 | 0.66 |

Presented at the Panama-Pacific Internationa Exposition meeting, San Francisco, September 1915, of THE AMERICAN SOCIETY OF MECANICAL ENGINEERS. The paper may be obtained in pamphlet form; price 10 cents to members, 20 cents to non-members. The previous paper by the senior author, No. 1382, may also be obtained in pamphlet form; price 25 cents to members, 50 cents to non-members.

vestigation divided itself into the following main divisions:

*a* Tests on 30T meshing with 40T, Brown & Sharpe 14½-deg. involute, at pitch speeds from 500 to 2000 ft. per min. to determine velocity coefficients, *v*, to supplement those derived in the earlier experiments for speeds below 500 ft. per min.[1]

*b* Tests on 30T meshing with solid 60, 80, 100, and 150T Brown & Sharpe 14½-deg. involute, to supplement earlier tests on effect of arc of action, to determine more fully arc of action influence.

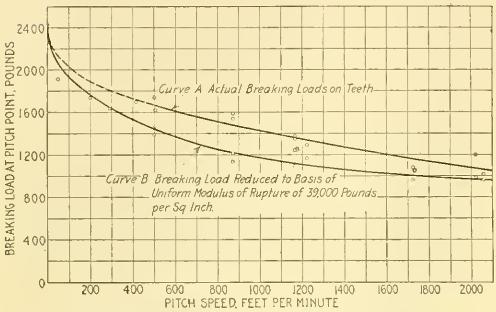



Fig. 2 Relation between Pitch Speed and Breaking Strength of Brown & Sharpe 30- and 40-Tooth 14½-Deg. Involute Gears

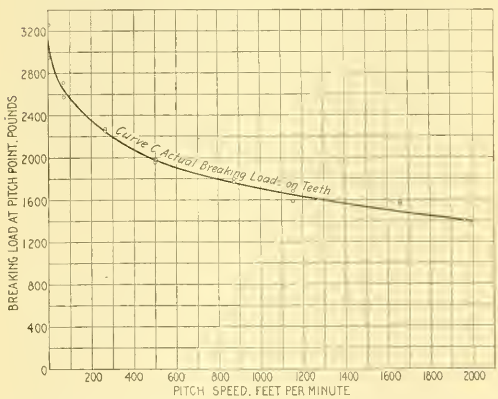



Fig. 3 Relation between Pitch Speed and Breaking Strength of Fellows 30- and 40-Tooth 20-Deg. Involute Stub-Tooth Gears

*c* Tests on 30T meshing with 40T, Fellows 20-deg. involute stub-tooth, for speeds from zero to 2000 ft. per min. to determine velocity coefficients, *v*, for this form of tooth.

*d* Tests on 30T meshing with 20, 40, 60, 80, and 100T, Fellows 20-deg. involute solid gears, on effect of arc of action, to determine arc of action coefficients, *a*, for this type of gear.

*e* Static tests on Fellows gears to determine actual breaking strength of individual teeth, for determination of experimental values of factors for form of tooth as determined by the number of teeth in gear (Lewis's factor *y*). See Par. 28, paper 1382.

The Brown & Sharpe gears were of their standard 10 diametral pitch, 14½-deg. involute form and those used in the tests involving the effect of pitch speed (Tests 1-12 inclusive) were sent from stock. These stock gears having a width of face of $1^3/_{16}$ in. were reduced by us to the width of $1^1/_{16}$ in. for which the apparatus had been constructed. The 30 and 60T gears were solid discs and the others were webbed, in order to eliminate the effect of weakness of arms and rims; the 80, 100 and 150T gears were made from patterns furnished by the authors. Solid grease lubricant liberally applied was used on all gears.

The Fellows gears were all of their $^{10}/_{12}$-pitch, 20-deg. involute form, and were solid discs in every case.

All gears when tested had the width of face of $1^1/_{16}$ in. The 20 and 30T gears (except the 30T gears of Tests 24A and 25A) had a bore of $1^1/_{16}$ in., and all others had a bore of $1^5/_{16}$ in.

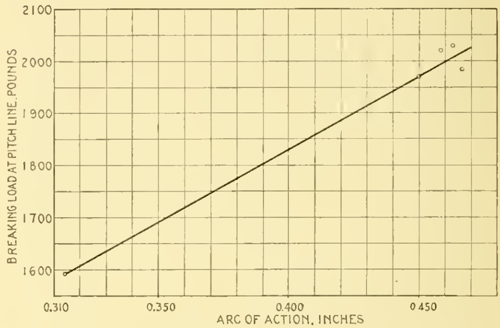



Fig. 4 Relation of Breaking Load to Arc of Action: Fellows 20-Deg. Involute at 500 Ft. per Min. Pitch Speed

The material (cast-iron) was tested in all cases by means of specimens cut from the gears themselves[1] and the results are given in detail in an appendix. The gears of each manufacture were furnished in two separate installments. The material of the gears furnished for the tests on influence of arc of action (Tests 13-20 and 18A-23A inclusive) was stronger in both cases than that of the gears previously furnished for the tests on influence of pitch speed (Tests 1-12 and 1A-17A inclusive). Where the variation of the strength of material was such as to call for a correction in order to get consistent and comparable results, this was made; but in all cases the actual test results are given first.

### Series A: Tests to Determine Velocity Coefficients, Brown & Sharpe Gears

Table 3 of velocity coefficients, *v*, (Par. 21, paper 1382), for Brown & Sharpe 14½-deg., cast-iron gears may be considered as quite definitely established for the entire range of speeds from zero to 2000 ft. per min. An explanation follows of the method by which these values were derived, from which it would appear to be safe to extrapolate beyond

[1] Par. 2, 7 and 21, paper 1382.

[1] Par. 22, paper 1382.

the speed of 2000 ft. per min., if desired,—safer than to make the tests. In fact, the authors are entirely willing to leave the conduct of all tests at higher pitch speeds to those who would like to see them made.

The data from which the values in Table 3 were derived are given in Tables 1 and 2 and in Fig. 2. Table 1 gives the results of the supplementary tests on the effect of speed on breaking strength of Brown & Sharpe 14½-deg. involute, 1¹/₁₆-in. face, 30T meshing with 40T. The experiments previously reported[1] for gears of these sizes and this type gave results up to a pitch speed of 415 ft. per min. These results, together with those of Table 1, are plotted in Fig. 2, Curve *A*.

In Par. 14 to 17 of Paper 1382, attention was called to an apparent rise of strength at speeds above 300 ft. per min. and the tentative suggestion advanced that this might be due to passing a maximum percussive effect. The tests at the speeds above 500 ft. per min. failed to maintain this view. Moreover, the tests on the Fellows gears reported on in a later section of this paper showed no such phenomenon. In the latter case ball bearings were used throughout for the series of tests involving 30T and 40T gears. The explanation of the irregularity of the Brown & Sharpe curve (including the phenomenon of its rise) lies in the use of ordinary journal bearings in the first set of experiments. The friction of the brake shaft bearings was neglected. In the original paper it was assumed that the only effect of this is to make the computed breaking load of the teeth a very little less than its real value in each case.

A study of journal friction and variations of coefficients of friction with speed, made by the senior author in another connection, clears up this matter. Without entering into detail, the coefficient of friction of the journals used in the earlier apparatus is a variable, being greatest at zero velocity and decreasing to a minimum at about the rotative speed corresponding to the pitch speed of 415 ft. per min. At this speed the coefficient of friction (perfect film lubrication) is not widely different from the practically uniform coefficient of friction for ball bearings. Had this variable effect of friction not been neglected, the actual curves would probably not have shown this fall and subsequent rise.

If due allowance be made for this frictional resistance and it be properly added to the observed breaking load in each case, the actual curve for the entire range would be approximately that shown by the dotted line up to the speed of 500 ft. per min., and the full line from there on to 2000 ft. per min. (Curve *A*, Fig. 2). A correction was made for the added

[1] Par 15, paper 1382.

TABLE 1 EFFECT OF SPEED ON BREAKING STRENGTH

Brown & Sharpe 14½-deg. Involute, 10-pitch, 1¹/₁₆-in. Face, 30T Meshing with 40T; 1st Series, 1914

| Test number | Cast Iron Gears | | 8-Pitch B. & S. Steel Change Gears | | | |
|---|---|---|---|---|---|---|
| | Pitch speed, ft. per min. | Equivalent load at teeth, pounds | Number of teeth | | Pitch speed | Equivalent maximum pitch load |
| | | | Driver | Driven | | |
| 1 | 501 | 1743 | 100 | 70 | 1462 | 598 |
| 2 | 507 | 1622 | 100 | 70 | 1479 | 556 |
| 3 | 872 | 1441 | 100 | 40 | 1454 | 864 |
| 4 | 872 | 1592 | 100 | 40 | 1454 | 955 |
| 5 | 1221 | 1289 | 70 | 20 | 1018 | 1547[1] |
| 6 | 1163 | 1380 | 100 | 30 | 1454 | 1104 |
| 7 | 1176 | 1259 | 100 | 30 | 1470 | 1007 |
| 8 | 1163 | 1350 | 100 | 30 | 1454 | 1080 |
| 9 | 1724 | 1078 | 100 | 20 | 1437 | 1293 |
| 10 | 1734 | 1047 | 100 | 20 | 1444 | 1257 |
| 11 | 2021 | 1199 | 120 | 20 | 1684 | 1438 |
| 12 | 2057 | 1017 | 120 | 20 | 1714 | 1221 |

[1]Steel gears abraded.

TABLE 2 REDUCTION OF BREAKING LOAD TO BASIS OF UNIFORM MODULUS OF RUPTURE OF 39,000 LB. PER SQ. IN.

Brown & Sharpe Gears

| Test number | Actual Modulus of rupture from table Appendix 2 | Conditions of Running Test | | | | Equivalent breaking load for modulus of rupture of 39,000 lb. per sq. in. |
|---|---|---|---|---|---|---|
| | | Teeth in C. I. driver | Teeth in C. I. driven | Actual breaking load at pitch line by test | Velocity at pitch line, ft. per min. | |
| 1 | 48,770 | 30 | 40 | 1743 | 501 | 1394 |
| 2 | 42,976 | 30 | 40 | 1622 | 507 | 1471 |
| 3 | 46,323 | 30 | 40 | 1441 | 872 | 1213 |
| 4 | 54,632 | 30 | 40 | 1592 | 872 | 1137 |
| 5 | 43,143 | 30 | 40 | 1289 | 1221 | 1165 |
| 6 | 49,040 | 30 | 40 | 1380 | 1163 | 1097 |
| 7 | 39,288 | 30 | 40 | 1259 | 1176 | 1249 |
| 8 | 42,382 | 30 | 40 | 1350 | 1163 | 1243 |
| 9 | 43,868 | 30 | 40 | 1078 | 1724 | 958 |
| 10 | 38,779 | 30 | 40 | 1047 | 1734 | 1053 |
| 11 | 47,400 | 30 | 40 | 1199 | 2021 | 987 |
| 12 | 41,300 | 30 | 40 | 1017 | 2057 | 961 |
| 13 | 69,600 | 30 | 60 | 2372 | 501 | 1329 |
| 14 | 59,460 | 30 | 60 | 2271 | 504 | 1489 |
| 15 | 58,840 | 30 | 80 | 1930 | 507 | 1279 |
| 16 | 59,300 | 30 | 80 | 2044 | 504 | 1344 |
| 17 | 55,850 | 30 | 100 | 1817 | 510 | 1269 |
| 18 | 59,840 | 30 | 100 | 2059 | 507 | 1342 |
| 19 | 66,620 | 30 | 150 | 1998 | 507 | 1170 |
| 20 | 61,100 | 30 | 150 | 1917 | 507 | 1224 |

TABLE 3 VELOCITY COEFFICIENTS ($v$). BREAKING LOAD ON TEETH REDUCED TO BASIS OF UNIFORM MODULUS OF RUPTURE

Brown & Sharpe 14½-deg. Involute Gears

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pitch velocity, ft. per min. . . | 0000 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1100 |
| Velocity coef., $v$. | 1.000 | 0.795 | 0.730 | 0.675 | 0.635 | 0.595 | 0.565 | 0.540 | 0.520 | 0.500 | 0.485 | 0.470 |
| Pitch velocity, ft. per min. . . | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | | | |
| Velocity coef., $v$. | 0.455 | 0.445 | 0.435 | 0.430 | 0.420 | 0.415 | 0.410 | 0.405 | 0.400 | | | |

TABLE 4 TESTS ON INFLUENCE OF ARC OF ACTION

BROWN & SHARPE 14½-DEG. INVOLUTE, 10-PITCH GEARS

| Test number | Number of Teeth C. I. Test Gears: Driver | Number of Teeth C. I. Test Gears: Driven | Pitch speed, ft. per min. | Equivalent breaking load at pitch line, pounds | Arc of action, inches[1] | Equivalent breaking load. Reduced to uniform modulus of rupture of 39,000 lb. per sq. in. |
|---|---|---|---|---|---|---|
| 1 | 30 | 40 | 501 | 1743 | 0.628 | 1394 |
| 2 | 30 | 40 | 507 | 1622 | 0.628 | 1471 |
| | | | | Av. 1683 | | Av. 1433 |
| 13 | 30 | 60 | 501 | 2372 | 0.649 | 1329 |
| 14 | 30 | 60 | 504 | 2271 | 0.649 | 1489 |
| | | | | Av. 2322 | | Av. 1409 |
| 15 | 30 | 80 | 507 | 1930 | 0.662 | 1279 |
| 16 | 30 | 80 | 504 | 2044 | 0.662 | 1344 |
| | | | | Av. 1987 | | Av. 1312 |
| 17 | 30 | 100 | 510 | 1817 | 0.671 | 1269 |
| 18 | 30 | 100 | 507 | 2059 | 0.671 | 1342 |
| | | | | Av. 1938 | | Av. 1306 |
| 19 | 30 | 150 | 507 | 1998 | 0.685 | 1170 |
| 20 | 30 | 150 | 507 | 1917 | 0.685 | 1224 |
| | | | | Av. 1958 | | Av. 1197 |

[1]See Appendix No. 3, Paper 1382, for discussion of determination of arc of action.

TABLE 5 COEFFICIENTS BASED ON ARC OF ACTION

BROWN & SHARPE, 14½-DEG. INVOLUTE GEARS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ratio: $\frac{\text{Arc of action}}{\text{Pitch arc}}$ .......... | 1 | 1.4 | 1.6 | 1.7 | 1.8 | 1.9 | 1.95 | 2.00 | 2.2 |
| Corresponding $a$.............. | 1 | 1.05 | 1.1 | 1.15 | 1.24 | 1.38 | 1.47 | 1 60 | 1.60 |

TABLE 6 FELLOWS 20-DEG. INVOLUTE STUB-TOOTH GEARS, $^{10}/_{12}$ PITCH, 1$\frac{1}{16}$-IN. FACE 30-TOOTH MESHING WITH 40-TOOTH

1st Series, 1914

| Test number | Cast Iron Gears: Pitch speed, ft. per min. | Cast Iron Gears: Equivalent load at teeth, lb. | 8-Pitch, B. & S. Steel Change Gears: No. of teeth, Driver | No. of teeth, Driven | Pitch speed, ft. per min. | Equivalent maximum pitch load, lb. |
|---|---|---|---|---|---|---|
| 13A | 0 | 2953 | .... | .... | .... | .... |
| 14A | 0 | 3256 | .... | .... | .... | .... |
| 1A | 72 | 2575 | 20 | 100 | 301 | 618 |
| 2A | 71 | 2711 | 20 | 100 | 297 | 651 |
| 3A | 266 | 2273 | 30 | 40 | 444 | 1364 |
| 4A | 266 | 2257 | 30 | 40 | 444 | 1354 |
| 5A | 501 | 1955 | 100 | 70 | 1462 | 670 |
| 6A | 501 | 1985 | 100 | 70 | 1462 | 681 |
| 7A | 872 | 1804 | 100 | 40 | 1454 | 1082 |
| 8A | 872 | 1773 | 100 | 40 | 1454 | 1064 |
| 9A | 1149 | 1683 | 100 | 30 | 1437 | 1346 |
| 10A | 1149 | 1592 | 100 | 30 | 1437 | 1274 |
| 11A | 1654 | 1577 | 100 | 20 | 1378 | 1892[1] |
| 12A | 1654 | 1562 | 100 | 20 | 1378 | 1874 |
| 16A | 1960 | 1403 | 120 | 20 | 1633 | 1683 |
| 17A | 1984 | 1380 | 120 | 20 | 1654 | 1656 |

[1]Log of test says, "The steel 20T showed about the limit of its endurance without abrasion."

TABLE 7 VELOCITY COEFFICIENTS ($v$), BASED ON ACTUAL BREAKING LOAD ON TEETH

FELLOWS 20-DEG. INVOLUTE, STUB TOOTH GEARS

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pitch velocity, ft. per min............... | 0000 | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 |
| Velocity coefficient, $v$.. | 1.000 | 0.825 | 0.755 | 0.705 | 0.665 | 0.635 | 0.615 | 0.595 | 0.580 | 0.565 | 0.550 |
| Pitch velocity, ft. per min............... | 1100 | 1200 | 1300 | 1400 | 1500 | 1600 | 1700 | 1800 | 1900 | 2000 | |
| Velocity coefficient, $v$.. | 0.540 | 0.525 | 0.515 | 0.505 | 0.495 | 0.485 | 0.475 | 0.470 | 0.460 | 0.450 | |

load on the gear due to journal friction for the test at zero velocity, assuming a value of 0.20 for the static coefficient of friction, giving as a result an added load of 175 lb. on the tooth, thus bringing the average value up to 2435 lb. for zero velocity. It is on the side of safety to base the coefficient of velocity, $v$, on this value.

The stock gears used in Tests 1 to 12 showed a wide variation in material as indicated by flexure tests. Since the material of the similar gears reported upon in Paper 1382 had a very uniform modulus of rupture of about 39,000 lb. per sq. in., it would seem better to reduce the actual results of the present experiments to a basis of a uniform modulus of rupture of 39,000 if the two sets of observations are to be combined. This has been done in the last column of Table 2. Fig. 2, Curve $B$, shows the results graphically. An explanation of this variation of strength probably lies in the reduction of the width of face of these gears after their receipt by us. The removal of one-eighth of an inch at one surface or the other would have a marked effect, since the surface material is recognized as being the stronger. If this material were removed on the side which originally had had the greater depth of cut taken from it in finishing the gear blank, the result would be different from that if the reduction in width had been made on the other surface.

Objection may be made to using Curve $B$ rather than Curve $A$ for the determination of the velocity coefficients. It is to be noted, however, that this reduction, made for the purpose of having the present and earlier experiments more justly comparable, also makes the present test results more consistent and it gives velocity coefficients which, being lower than those which would be derived from Curve $A$, are on the side of additional safety.

### SERIES B: TESTS TO DETERMINE INFLUENCE OF ARC OF ACTION, BROWN & SHARPE GEARS

The experiments under this head were originally planned (when the gears for the series were ordered) to supplement those on the influence of arc of action, described in Par. 32, paper 1382, and shown there in Fig. 9, Curve $B$; but subsequently it was decided to run the tests independently of the previous ones, at a pitch speed of approximately 500 ft. per min., in order to make them comparable with the Fellows tests, Nos. 5A, 6A, 18A, to 23A inclusive, described later in the present paper, which had already been made at this speed. Table 4 gives the results.

The unusually high modulus of rupture shown by the material of most of the gears used in this set of tests, made it seem desirable to adopt the expedient of reducing the actual

test results to a basis of an imaginary uniform material having a modulus of rupture of 39,000 lb. per sq. in.

It is impossible, however, to get any satisfactory light out of this series of tests on the actual influence of the arc of action. While the unmodified results, with the exception of Tests 13 and 14, are not incompatible with those obtained in the earlier paper, when reduced to a basis of a uniform modulus of rupture they show an apparent falling off of breaking strength with increase of arc of action for ratios of arc of action to pitch arc greater than 2. This may actually be the case, but it is contrary to the effect of ratio of arc of action to pitch arc for values ranging from 1 to 2 and does not seem rational. It is also contrary to the results given in Tables 10-14, paper 1382.

It must be borne in mind that reducing the tests to a uniform modulus of rupture on the basis of a test bar cut from the gear is only a crude expedient adopted in default of a better. Cast iron is too variable a material to permit certainty that the strength at the tooth which first yielded was just that of the test bar. In addition, we have the fact that the teeth do not fail by pure flexure and that, therefore, using the modulus of rupture for flexure as the unifying basis is open to some question. But it is equally evident that material which showed as much variation as did this calls for the reduction of test results to some kind of comparable basis.

Thinking that the discrepancy of the results might be due to the possible failure of the teeth of the larger gear rather than the smaller, owing to the chance of weaker material in the larger gears, test bars were cut from the 60T and 80T gears of Tests 13 and 15. While the material proved to be a little weaker than that of the corresponding 30T pinions, computations showed that this was more than compensated for by the stronger form of the teeth of the larger gears. This possible explanation of the discrepant results also had to be abandoned.

Another explanation of the reduced results running in the wrong direction may lie in the possibility that the shafts were not exactly parallel. This would cause severer stress conditions the larger the radius of the gear.

Weighing all the evidence, we consider that the arc of action coefficients, *a*, derived in the earlier paper from experiments on more uniform and normal material, are essentially correct and they are repeated here in Table 5, being extended to a ratio of

$$\frac{\textit{arc of action}}{\textit{pitch arc}} = 2.2$$

From the way an additional tooth comes into action, as shown by the imperceptible increase

TABLE 8 REDUCTION OF BREAKING LOAD TO BASIS OF UNIFORM MODULUS OF RUPTURE OF 39,000 LB. PER SQ. IN.

FELLOWS 20-DEG. INVOLUTE GEARS

| Test number | Actual modulus of rupture from table Appendix 2 | Conditions of Running Test | | | | Equivalent breaking load for modulus of rupture of 39,000 lb. per sq. in. |
|---|---|---|---|---|---|---|
| | | Teeth in C. I. driver gear | Teeth in C. I. driven gear | Actual breaking load at pitch line by test | Velocity at pitch line, ft. per min. | |
| 1A | 40,420 | 30 | 40 | 2575 | 72 | 2485 |
| 2A | 38,977 | 30 | 40 | 2711 | 71 | 2713 |
| 3A | 42,415 | 30 | 40 | 2273 | 266 | 2089 |
| 4A | 36,403 | 30 | 40 | 2257 | 266 | 2418 |
| 5A | 35,920 | 30 | 40 | 1955 | 501 | 2123 |
| 6A | 39,250 | 30 | 40 | 1985 | 501 | 1972 |
| 7A | 39,450 | 30 | 40 | 1804 | 872 | 1783 |
| 8A | 39,771 | 30 | 40 | 1773 | 872 | 1739 |
| 9A | 36,890 | 30 | 40 | 1683 | 1149 | 1779 |
| 10A | Not tested | 30 | 40 | 1592 | 1149 | Blow hole |
| 11A | 39,262 | 30 | 40 | 1577 | 1654 | 1567 |
| 12A | 38,240 | 30 | 40 | 1562 | 1654 | 1593 |
| 13A[1] | 44,480 | 30 | 40 | 2953 | 0000 | 2589 |
| 14A | 44,480 | 30 | 40 | 3256 | 0000 | 2855 |
| 15A | 44,480 | 30 | 40 | 3861[2] | 0000 | Void |
| 16A | 43,897 | 30 | 40 | 1403 | 1960 | 1247 |
| 17A | 38,850 | 30 | 40 | 1380 | 1984 | 1386 |
| 18A | 46,030 | 30 | 80 | 1643 | 507 | 1392[3] |
| 19A | 46,900 | 30 | 80 | 2029 | 507 | 1688 |
| 20A | 45,310 | 30 | 100 | 1907 | 507 | 1642 |
| 21A | 46,460 | 30 | 100 | 2059 | 507 | 1729 |
| 22A | 44,190 | 30 | 60 | 1969 | 507 | 1738 |
| 23A | 44,860 | 30 | 60 | 2070 | 507 | 1800 |
| 24A | .... | 20 | 30 | 1477 | 476 | .... |
| 25A | .... | 20 | 30 | 1437 | 476 | .... |

[1]Same gears used in tests 13A, 14A and 15A.
[2]Void. Not weakest position.
[3]Void. See log of test.

TABLE 9 ARCS OF ACTION

COMBINATIONS OF $^{10}/_{12}$ PITCH GEARS FELLOWS 20-DEG. INVOLUTE

| Gear Teeth | | Arc of action, inches | Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$ |
|---|---|---|---|
| Driver | Driven | | |
| Single tooth engagement | Weakest position[1] | 0.31416 | 1.0000 |
| 12 | 12 | 0.38760 | 1.2334 |
| 20 | 30 | 0.43109 | 1.3722 |
| 30 | 40 | 0.45008 | 1.4327 |
| 30 | 60 | 0.45844 | 1.4591 |
| 30 | 80 | 0.46319 | 1.4744 |
| 30 | 100 | 0.46643 | 1.4852 |
| 30 | Rack | 0.48075 | 1.5271 |
| 100 | 100 | 0.48996 | 1.5596 |
| 100 | Rack | 0.50427 | 1.6051 |

[1]Position A, Table 8, Paper 1382.

TABLE 10 INFLUENCE OF ARC OF ACTION

FELLOWS 20-DEG. INVOLUTE GEARS

STATIC TESTS

| Test number | Conditions of test | Breaking load at pitch line, pounds | Arc of action, inches | Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$ |
|---|---|---|---|---|
| 1B | 30 T, position "A"........ | 2536 | 0.31416 | 1.0000 |
| 2B | 30 T, position "A"........ | 2475 | 0.31416 | 1.0000 |
| | | Av. 2506 | 0.31416 | 1.0000 |
| 13A | 30 T, driving 40 T......... | 2953 | 0.45008 | 1.4327 |
| 14A | 30 T, driving 40 T......... | 3256 | 0.45008 | 1.4327 |
| | | Av. 3105 | 0.45008 | 1.4327 |

TABLE 11 INFLUENCE OF ARC OF ACTION AT APPROXIMATELY 500 FT. PER MIN., PITCH SPEED

Fellows 20-deg. Involute Gears

| Test number | Gear Teeth | | Pitch speed ft. per min. | Breaking load at pitch line, pounds | Arc of action, inches | Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$ |
|---|---|---|---|---|---|---|
| | Driver | Driven | | | | |
| 5A | 30 | 40 | 501 | 1955 | 0.45008 | 1.4327 |
| 6A | 30 | 40 | 501 | 1985 | 0.45008 | 1.4327 |
| | | | | Av. 1970 | 0.45008 | 1.4327 |
| 22A | 30 | 60 | 507 | 1969 | 0.45844 | 1.4590 |
| 23A | 30 | 60 | 507 | 2070 | 0.45844 | 1.4590 |
| | | | | Av. 2020 | 0.45844 | 1.4590 |
| 19A | 30 | 80 | 507 | 2029 | 0.46319 | 1.4744 |
| | | | | Av. 2029 | 0.46319 | 1.4744 |
| 20A | 30 | 100 | 507 | 1907 | 0.46643 | 1.4852 |
| 21A | 30 | 100 | 507 | 2059 | 0.46643 | 1.4852 |
| | | | | Av. 1983 | 0.46643 | 1.4852 |

TABLE 12 COEFFICIENTS ($a$), BASED ON ARC OF ACTION

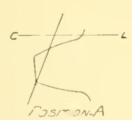
Fellows 20-deg. Involute, Stub Tooth Gears

| Teeth in Engaging Gears | | Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$ | Corresponding $a$ |
|---|---|---|---|
| Single tooth engagement | | 1.0000 | 1.00 |
| 12 | 12 | 1.2334 | 1.13 |
| 20 | 30 | 1.3722 | 1.20 |
| 30 | 40 | 1.4327 | 1.24 |
| 30 | 60 | 1.4591 | 1.25 |
| 30 | 80 | 1.4744 | 1.26 |
| 30 | 100 | 1.4852 | 1.27 |
| 30 | Rack | 1.5271 | 1.29 |
| 100 | 100 | 1.5596 | 1.31 |
| 100 | Rack | 1.6051 | 1.33 |

TABLE 13 EQUIVALENT STATIC BREAKING LOADS ($W$), AT PITCH LINE

Fellows 20-deg. Involute, Stub Tooth, $^{10}/_{12}$ Pitch Gears

POSITION OF STRESSED TOOTH



| Teeth in gear | Test number | Equivalent breaking load, $W$, pounds | Average $W$, pounds | $y = \frac{W}{s\,p\,f}$ ($s\,p\,f = 13{,}656$) |
|---|---|---|---|---|
| 20 | 3B | 1702 | | |
| 20 | 4B | 1762 | 1732 | 0.127 |
| 30 | 1B | 2526 | | |
| 30 | 2B | 2486 | 2506 | 0.184 |
| 40 | 5B | 3029 | 3029 | 0.222 |
| 60 | 7B | 3582 | | |
| 60 | 8B | 3481 | 3532 | 0.259 |
| 80 | 9B | 3443 | | |
| 80 | 10B | 3858 | | |
| 80 | 11B | 3631 | 3643 | 0.267 |
| 100 | 12B | 3803 | 3803 | 0.279 |

of $a$ for the range from a ratio of 1 to a ratio of 1.4, it is probable that the value of $a$ remains at about 1.6 from a ratio of 2 to a ratio of 2.4.

The gears employed in Tests 13 to 20 inclusive were made from special patterns sent to the manufacturers. All of them were solid or webbed and the hubs were lengthened to permit a 2½-in. key being used; this precaution being necessary because of the longer lever arm of the tooth load.

It was intended to carry out tests on the static strength of the individual teeth of these gears, as shown in position $A$, Table 8, paper 1382, but because of the exceptional strength of the material, which caused the shaft to spring, it was not certain that the teeth were being held in the proper relation at the instant of rupture and this purpose was abandoned. The experimental value of the factor for form of tooth (Lewis's factor $y$), as determined in Par. 29 and Appendix 4, paper 1382, is therefore retained, being—for the Brown & Sharpe 14½-deg. involute teeth—equal to

$$\left(0.154 - \frac{1.26}{n}\right)$$

where $n$ is the number of teeth in the gear.

### SERIES C: TESTS TO DETERMINE VELOCITY COEFFICIENTS, FELLOWS GEARS

The tests for effect of pitch velocity on the breaking strength of Fellows 20-deg. involute, stub-tooth gears, $^{10}/_{12}$-pitch, $1\,^{1}/_{16}$-in. face, 30T meshing with 40T, gave remarkably uniform and consistent results. These are tabulated in Table 6 and shown graphically in Fig. 3. This uniformity is in a large measure due to the uniformity of the material of this set of gears, but may also have been influenced by the method of cutting. We had no apparatus to measure accuracy of tooth spacing and made no attempt to do so.

From the curve of Fig. 3, Table 7 of velocity coefficients, $v$, for Fellows 20-deg. involute gears has been computed. It will be noted that these values of $v$ correspond quite closely to those obtained in the experiments with the Brown & Sharpe gears. (Compare Table 3.)

In the case of the Fellows tests the expedient of plotting the breaking loads reduced to a uniform modulus of rupture, and basing the velocity coefficients upon this curve, was not resorted to, as it was in the case of the Brown & Sharpe tests. The material of the gears used in this set of tests, 1A to 17A inclusive, being from a single melt, showed only moderate variation in the flexure tests and had an average modulus of rupture of 39,600 lb. per sq. in. For this reason, and for the further reason that the velocity coefficients derived from the reduced curve would be slightly higher than those derived from the actual test results and therefore

tend away from safety rather than toward it, no curve is drawn in Fig. 3 reducing the actual test results to a uniform basis of a modulus of rupture of 39,000 lb. per sq. in. Table 8, however, gives the results of reduction computations in the same manner as shown in Table 2 for the Brown & Sharpe gears and is included here to complete the record. If the modified results be plotted it will be noted that they are not as regular and consistent as the actual test results.

SERIES D: TESTS TO DETERMINE ARC OF ACTION COEFFICIENTS, FELLOWS GEARS

The shortened addendum used in the Fellows system makes for shorter and less varied arcs of action. By the method described fully in Appendix 3 of paper 1382, the values of the arcs of action for various combinations of Fellows gears were computed. The results are given in Table 9.

Tables 10 and 11 give the results of those experiments which were made to determine the effect of arc of action on breaking strength in the case of the Fellows gears. From Table 10 it is seen that in the static tests there is an increase in strength in the ratio of $^{3105}/_{2506} = 1.24$ for an increase in arcs of action in the ratio of

$$\frac{0.45008}{0.31416} = 1.4327$$

Taking account of the single tooth, weakest position, static strength of the 30T gear 2506 lb. as shown by the average of Tests 1B and 2B, and multiplying by the velocity coefficient 0.635 for 500 ft. per min., we get 1591 lb. as the breaking strength at this speed for a 30T Fellows gear with an arc of action of 0.31416.[1] This point is plotted in Fig. 4 with the averages of Table 11, which therefore shows the relations between equivalent breaking load and arc of action for the Fellows gears at this speed.

An interesting check is to compare with the results of Table 10, the increase for strength at this speed of 500 ft. per min., for an increase of arc of action from 0.31416 to 0.45008. The ratio of increase of strength is $^{1970}/_{1591} = 1.24$, as before.

Objection may be made to there being too few points to locate the curve of Fig. 4 with reasonable accuracy. As seen in the next paragraph the matter is not vital. The variation in value of the arc of action coefficient, $a$, in all cases except those involving very small pinions, is so slight that no appreciable error is introduced if it be taken as uniformly equal to 1.25 in the case of the Fellows gears.

Table 12 gives values for the arc of action coefficient,[2] $a$, as deduced from Fig. 4 for the gear combinations of Table 9 as covering the ordinary range. The values for others can be computed readily or interpolated with sufficient accuracy. It can be seen that $a = 1.33$ is about the maximum value in any practical case as compared with a corresponding maximum of about 1.60 for the Brown & Sharpe system.

TABLE 14 SUMMARY OF INVESTIGATION OF BREAKING STRENGTH OF BROWN & SHARPE 14½-DEG. INVOLUTE, AND FELLOWS 20-DEG. INVOLUTE, STUB-TOOTH, CAST-IRON, CUT GEARS

SYMBOLS, BOTH SYSTEMS

$W$ = safe equivalent load at pitch line, pounds
$s$ = modulus of rupture = 36,000 lb. per sq. in. for cast iron
$p$ = circular pitch, inches = pitch arc
$f$ = width of face of gear, inches
$n$ = number of teeth in gear
$k$ = factor of safety
Suggested values: $k = 4$, for steady load, no reversal of stress
$k = 6$, suddenly applied load, no reversal of stress
$k = 8$, suddenly applied load, with reversal of stress
$v$ = velocity coefficient. See tables
$a$ = arc of action coefficient. See tables

FORMULÆ

Brown & Sharpe 14½-deg. involute:

$$W = \frac{spf}{k}\left(0.154 - \frac{1.26}{n}\right) va$$

Fellows 20-deg. involute, stub tooth:

$$W = \frac{spf}{k}\left(0.278 - \frac{2.69}{n}\right) va$$

Neither formula holds for values of $n$ less than 12.

VALUES OF ($v$)

| Pitch velocity, ft./min. | $v$ Brown & Sharpe 14½-deg. involute | $v$ Fellows 20-deg. involute stub tooth | Pitch velocity, ft./min. | $v$ Brown & Sharpe 14½-deg. involute | $v$ Fellows 20-deg. involute stub tooth |
|---|---|---|---|---|---|
| 0000 | 1.000 | 1.000 | 1100 | 0.470 | 0.540 |
| 100 | 0.795 | 0.825 | 1200 | 0.455 | 0.525 |
| 200 | 0.730 | 0.755 | 1300 | 0.445 | 0.515 |
| 300 | 0.675 | 0.705 | 1400 | 0.435 | 0.505 |
| 400 | 0.635 | 0.665 | 1500 | 0.430 | 0.495 |
| 500 | 0.595 | 0.635 | 1600 | 0.420 | 0.485 |
| 600 | 0.565 | 0.615 | 1700 | 0.415 | 0.475 |
| 700 | 0.540 | 0.595 | 1800 | 0.410 | 0.470 |
| 800 | 0.520 | 0.580 | 1900 | 0.405 | 0.460 |
| 900 | 0.500 | 0.565 | 2000 | 0.400 | 0.450 |
| 1000 | 0.485 | 0.550 | .... | .... | .... |

VALUES OF ($a$)

| Teeth in engaging gears | | Corresponding $a$ Brown & Sharpe 14½-deg. involute | Corresponding $a$ Fellows 20 deg involute stub tooth |
|---|---|---|---|
| Single tooth engages | | 1.00 | 1.00 |
| 12 | 12 | 1.10 | 1.13 |
| 20 | 30 | 1.15 | 1.20 |
| 30 | 30 | 1.47 | 1.22 |
| 30 | 40 | 1.60 | 1.24 |
| 30 | 60 | 1.60 | 1.25 |
| 30 | 80 | 1.60 | 1.26 |
| 30 | 100 | 1.60 | 1.27 |
| 30 | Rack | 1.60 | 1.29 |
| 100 | 100 | 1.60 | 1.31 |
| 100 | Rack | 1.60 | 1.33 |

SERIES E: DETERMINATION OF VALUE OF FACTOR Y, LEWIS FORMULA

The next step in the investigation of the Fellows gears was the determination of the expression for the factor depending upon the change of tooth-form as dictated by the number of teeth in the gear. This is Mr. Lewis's well-known factor $y$. For a 20-deg. involute tooth with addendum equal to 0.8 ÷ diametral pitch, Mr. Flanders[3] gives values from which we obtain

$$y = \left(0.173 - \frac{0.720}{n}\right)$$

By laying out the form of the 12, 30, 40 and rack teeth of

[1] Par. 32, paper 1382.

[2] Par. 33, paper 1382.

[3] Trans. A. S. M. E., vol. 30, p. 930.

the actual Fellows $^{10}/_{12}$-pitch, ten times full size, and employing the method described in Appendix 2, paper 1382, we obtained

$$y = \left(0.169 - \frac{0.972}{n}\right)$$

As was found in regard to the similar factor for the Brown & Sharpe system[1] this method, based upon an unmodified flexure theory, does not correspond to actual conditions. The teeth in every case show much greater breaking strength than either of these values of $y$ would give when substituted in the single tooth static strength formula, $W = spfy$.

A series of tests was made on the static strength of single teeth under conditions of load application corresponding to engagement at their weakest position. This is Position $A$

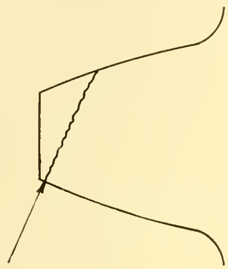


Fig. 5 Manner of Tooth Failure

of Table 8, paper 1382, and corresponds to the maximum strength of such gears when the arc of action is just equal to or is less than the pitch arc (i.e., circular pitch). In this case both velocity coefficient and arc of action coefficient become equal to unity and the value of $y$ can be computed directly. The loads were applied by means of a steel pinion. Par. 27, paper 1382. The results of these tests are given in Table 13. In computing the values of $y$, $s$ is taken equal to the average shown by all the Fellows test specimens, 40,910 lb., $p = 0.31416$ in.; and $f = 1.0625$ in.

By the method of Appendix 4, paper 1382, these results give approximately a value of

$$y = \left(0.317 - \frac{3.81}{n}\right)$$

But an examination of this equation shows that it would lead to a zero value of $y$, and hence of $W$, for $n = 12$, which is obviously incorrect. It would also lead to a value of $W = 4329$ for a rack tooth ($n = \infty$); while the experiments showed that the teeth would fail by shear, as indicated in Fig. 5, rather than by flexure, long before such a load could be reached. A note made in the log at the time of these tests says: "It seems a fair conclusion that these stub-teeth when loaded at the end are apt to fail by shear before reaching a load that would break them out, in the case of 60T gears and larger." Our judgment based upon observed experiments was that this limiting value for a rack tooth end load would be 3800 lb. Upon this basis and by combination with $W$ for $n = 20$, 30 and 40,

$$y = \left(0.278 - \frac{2.69}{n}\right)$$

was deduced. The results derived from its use checked very closely with the actual running test results. Where they depart from the test results in the static cases they do so on the safe side.

It is to be borne in mind that we questioned the test results in these static tests above 40T gears, as we noted in the log that because of the torsional deflection of the shafts we could not be certain that the teeth were in position $A$ at the instant of rupture. Any deflection would put them in a position to carry a heavier load.

In the Fellows system of tooth forms the ratio of addendum to pitch is not a constant one for different pitches, hence the results obtained on $^{10}/_{12}$-pitch gears do not hold with exactness for other pitches. However, the differences in tooth proportions are not sufficiently great to forbid the use of these results with a reasonably close degree of accuracy for other pitches.

### CONCLUSIONS FROM ENTIRE SERIES OF TESTS

For convenient reference the conclusions arrived at from the entire experimentation, reported upon in both this paper and No. 1382, are summarized in Table 14. The formulae and factors represent the best judgment of the present writers, based upon painstaking and unprejudiced study of the complete data. The original goal of the investigation, namely the definite determination of the effect of pitch-speed upon breaking strength, has been attained, we feel, for the ordinary working range of velocities.

TABLE 15 CHECK OF FELLOWS FORMULA

| Test number | $W$, by test | $W$, by formula $s = 39{,}588$ |
|---|---|---|
| 1A | 2575 | 2622 |
| 2A | 2711 | 2629 |
| 3A | 2273 | 2225 |
| 4A | 2257 | 2225 |
| 5A | 1955 | 1957 |
| 6A | 1985 | 1957 |
| 7A | 1804 | 1753 |
| 8A | 1773 | 1753 |
| 9A | 1683 | 1642 |
| 10A | 1592 | 1642 |
| 11A | 1577 | 1480 |
| 12A | 1562 | 1480 |
| 13A | 2953 | 3081 |
| 14A | 3256 | 3081 |
| 15A | Void | .... |
| 16A | 1403 | 1399 |
| 17A | 1380 | 1393 |

Too much stress must not be laid upon the comparison, in individual cases, of the formula results and the test results reduced to the modulus of 36,000. In the non-homogeneous material, like cast-iron, the chances are altogether against the strength of the single test-specimen being exactly that of the tooth which first broke in the gear test. This is borne out by the fact that the actual test value of $W$ sometimes comes out larger in the case of duplicate experiments (all

[1] Par. 29, paper 1382.

conditions the same) for the gear whose material subsequently showed the lower modulus of rupture in the flexure tests. (Examples: Tests 1A and 2A, 3A and 4A.) Again, in many duplicate tests where the differences in breaking strength lay in the same direction as the differences in test-specimen moduli, the tooth strength variation was not as great as the variation in modulus. Examples:

Tests 1 and 2; Ratio of Moduli, 1.135; Ratio of $W$, 1.075
Tests 4 and 3; Ratio of Moduli, 1.179; Ratio of $W$, 1.105
Tests 6 and 8; Ratio of Moduli, 1.157; Ratio of $W$, 1.022
Tests 9 and 10; Ratio of Moduli, 1.131; Ratio of $W$, 1.029

To get a better check of the formula, therefore, we may select Tests 1A-17A, inclusive, of the Fellows gears which were made from a single melt whose average modulus of rupture was 39,588 lb., substitute this value of $s$ in the formula, and compare with the actual breaking test results. This is done in Table 15.

#### COMMENTS ON TESTS

The method of testing these gears was employed after due consideration, despite the criticisms made upon it in the discussion of the previous paper. It has the great merit of being both simple and positive. The apparatus is relatively inexpensive and requires no calibration. Since the chief criticisms were directed against the power consumption, meter readings were kept for the entire series of runs. The total power consumption as shown by the recording meter was only 150 kw-hr. The power cost is therefore inappreciable. Were these experiments on wear or endurance, rather than breaking strength, the cost of the power might enter into the problem as a determining factor and indicate the necessity for some such apparatus as that described by Wilfred Lewis at the June, 1914, meeting of the Society[1] However, with rupture tests, judging from our experience with the way the teeth are thrown at high speeds, it would seem inevitable that fractured cast-iron teeth would fall between the teeth of the steel gear and pinion and wreck the Lewis machine. It is also a question whether the steel gears (unless made of special material and heat-treated), necessarily having the same pitch and pitch-speeds as the cast-iron test gear, would be able to stand up without destructive abrasion under the load which would be required to break the cast-iron teeth. Our own experience (Tests 5 and 11A) leads us to doubt that ordinary, unhardened, steel gears would stand up under these conditions. To carry out our static tooth strength tests, where the load was directly applied by 10-pitch steel pinions, we found it necessary to case-harden these steel pinions.

These experiments, incidentally, give data on the carrying power shown by soft steel gears of the $14\frac{1}{2}$-deg. involute form, 8-pitch, $1\frac{1}{16}$-in. face, at pitch speeds ranging up to 1700 ft. per min. (See Tables 1 and 6.) Under the conditions of lubrication here employed the limiting load seems, roughly, to be about 1500 lb. per in. width of face for these gears.

In respect to the ball bearings in the improved testing apparatus, some light is thrown indirectly upon the carrying power of such bearings under rather severe conditions; for it must be borne in mind that the bearings were running, at the instant of rupture, in some cases at as high a rotative speed as 2500 r.p.m. and that the actual suddenly applied stress upon them, after the teeth began to break and wedge, must have been much greater even than the recorded breaking strength of the teeth, high as this was.

The tests were made in the laboratories of the Leland Stanford Junior University and the writers wish to express their appreciation of the cordial coöperation of the university authorities. Particular thanks are due Prof. W. F. Durand, executive head of the department of mechanical engineering, and to Prof. W. R. Eckart, in charge of the experimental engineering laboratories. Both the Brown & Sharpe Manufacturing Company and the Fellows Gear Shaper Company generously donated the gears necessary for the experiments.

[1] Trans. A. S. M. E., vol. 36, p. 231.

# CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

*Provisions have been made by the Publication Committee for Correspondence Departments in The Journal as follows: A Department for contributed discussions on papers previously published, or new matter. A Members' Correspondence department including suggestions on Society affairs.*

*Contributions for these departments are earnestly solicited.*

## ON MEASURING GAS WEIGHTS

To the Editor:

Mr. Butterfield, in his paper on Measuring Gas Weights (The Journal, August, 1915), is to be commended in his desire to have weight of gas, as well as of air, as a standard. However, it is greatly to be doubted if the universal custom in this connection of always using cubic feet, can ever be superseded. I have made several attempts in this direction, but have found the effort so unpopular that it had to be abandoned. I, therefore, recommend the following as being the nearest practical attainment of Mr. Butterfield's idea.

Amounts of air or gas delivered by fans, blowers, centrifugal or reciprocating compressors, should be given as cubic feet, referred to a fixed pressure and temperature. I have used 14.7 lb. per sq. in. abs. (at sea level and 45 deg. north latitude, if such precision is needed) and 60 deg. fahr. temperature and have called the quantities so given "cu. ft. of standard air," or "standard gas." 70 deg. and 62 deg. have also been used. It would be desirable if a single temperature could be agreed on.

A cubic foot of standard air or standard gas is a unit of weight just as Mr. Butterfield suggests, but does not involve a serious departure from customary practice. Another definite unit, which is not a unit of weight but which must be kept in mind, is a cubic foot at atmospheric conditions. The weight of such a unit varies with barometer, altitude and atmospheric temperature. The unit most interesting to a designer of a fan or compressor is the cubic foot at the average atmospheric conditions of the point of installation, and this is usually to be understood when cubic feet of a fan, etc., is specified without qualification. The term "cu. ft. of free air" or "free gas" is often used without statement as to whether cubic foot of standard air or cubic foot of air at average atmospheric conditions is meant. Hence, the use of this term without definition should be avoided.

Sanford A. Moss.

Lynn, Mass.

## OPPORTUNITY FOR THE ENGINEER IN CHINA

*To the Editor:*

There are, undoubtedly, many members of the Society who are engaged in business which, under certain conditions, would find a great and remunerative field in the Orient and especially in China. There are many, too, who have never given the matter any serious consideration. To such and all it will pay to turn attention China-ward for a little while and take note of the fast and favorably changing conditions there.

There seems to be considerable interest in Chinese business circles, just now, in the development of China's great, natural resources and their utilization in manufacturing and agriculture. Many inquiries are going about as to the cost of installing and running plants in a variety of manufacturing lines. While these may not materialize into large orders at once, on account of the high rate of exchange against China just now, and from other causes, still it shows a strong movement in the right direction of a tide which, if taken advantage of soon, should lead to good results to all parties concerned, but if neglected can never be regained.

There are several causes which have tended to stimulate this movement:

*a.* The European war has cut off China's facilities for borrowing and thrown her back on her own resources for raising funds; this was a good thing for China as it emphasized the value and importance of her rich assets and led many to look for means for using them.

*b.* The attitude of a neighboring nation which formerly supplied many manufactured articles to China has stirred up a strong feeling of revulsion which has started up a boycott all over the country, that is not an ordinary boycott, for there does not seem to be any official organization, but rather a spontaneous action which has been an impetus to supply, by home manufacture, as many of the things as possible that formerly were obtained from that country.

*c.* The ever increasing number of foreign educated men realize the value of China's resources and are seeking to introduce, to develop them, methods which they have learned of or seen abroad; this is becoming a stronger factor every year, especially in the case of the men returning from the United States.

It is coming to be recognized by Chinese business men that Chinese capital combined with the technical skill and knowledge of America and other advanced countries is what is needed here. As soon as financial conditions are favorable they will be ready to start operations; in the meantime they are gathering facts and figures as much as possible to be ready at the psychological moment. Why should not American manufacturers and machine builders be as astute and far sighted as these Chinese only recently awakened to our civilization?

Although the enterprises that are contemplated may be financed by Chinese capital or a combination of Chinese and American, there will, naturally, be a great opening for American machinery and manufactured goods of many kinds. Many new wants will be created by the new outlook and improved conditions.

In order to get this trade it is very desirable that as many American firms as possible get well represented here so that each nationality may get well acquainted and familiar before they begin to place orders. If the matter is delayed until the tide begins to turn it will be too late to get the proper benefits because it takes considerable time to get a good footing in such a market. Other nations, keen for the market, have been long established here but are more or less handicapped by the European war.

American goods and methods of business are much appreciated and more of the former would meet with favor if they were only here. Every student who returns from the United States has a soft spot in his heart for that country and its institutions. They form a large part of the foreign educated men. A large percentage of them get into influential places in business or the government and do not forget the good things they saw and learned abroad. Their number increases yearly.

As an aid in promoting trade between America and China, a Sino-American Bank is about to be established with sound backing in both countries. The preliminaries have already been settled by the recent Commercial Commission to America. New steamship lines are about to be organized through the same agencies.

American firms represented by Americans are not very numerous in this field yet but a few new ones are beginning to appear, here and there, which is an encouraging sign. It is the height of folly to let American firms be represented here by some other foreign nationality. That course has been taken by some but, to the resident here, the folly is apparent.

Although certain lines of American machine makers are very busy with orders in connection with the war, all those who can do so should turn their attention to the Chinese market, for a while at least, until a good foothold is established. Those who are well established here in the next year or two will have a prodigious advantage over the later comers and would be well repaid for their forethought. The Chinese are keen and reliable business people, are wide awake to the situation and will appreciate any sincere effort to boost things along here.

What would seem like a good proposition for some industries would be for several firms in allied lines to get together and establish a depot for their goods with a fairly good stock on hand for prompt delivery. The ability to show the goods and demonstrate the machinery will go a great way toward filling the order book. What is necessary is to get the goods in the front window where everybody can see them. The country best prepared for eventualities will win out in this race. *It is for Americans to decide whether they will let this opportunity slip through their hands or not.*

In some cases it might be well to arrange with Chinese capitalists to start branch works of American concerns with skilled American technicians in control of the producing side of the business, using such methods and appliances as seem best suited to the conditions here. The materials are here, good mechanics are here and the ready market. This is a field worth investigating. The Chinese are about one fourth of the world's population!

Trusting that this is of interest as coming from one in the field who has the interests of the United States and its industries at heart, I remain,

Sincerely yours,

Frank A. Foster.

Tientsin, China.

# FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

## ENGINEERING SURVEY

"In modern German plants for the preparation of powdered coal for firing furnaces, the following is the accepted fundamental principle: simplicity of machinery and apparatus used and accessibility of the whole arrangement. In this respect the German construction differs materially from the American, and even though some typically American crushers, such as the Fuller-Lehigh system, have been adopted in some German plants, as a rule they have not found ready application in that country and for the same reason, the high speed machinery of this type built in Germany itself, has not been much used."

The above is a quotation from an abstract of an article in the important German periodical, *Stahl und Eisen*, an organ of the German Association of Metallurgists. In the common struggle for markets in which it is hoped the American industries will try to get the share to which the resources of the country and genius of its engineers entitle it, it will be of great value to engineers to know the operating conditions and perhaps even the idiosyncrasies of foreign markets.

### This Month's Articles

In the section, Firing, is reported an article on the preparation of powdered coal and its firing in Germany, describing mainly the so-called Polysins system, viz., a crusher and grinder, the two combined, driving drums and layout of an ideal powdered coal fired plant.

In the section, Internal Combustion Engineering, is reported in brief an interesting investigation on the process of combustion occurring in a hot bulb engine.

Under Steam Engineering are given some data on the comparative commercial advantages and disadvantages of live steam and exhaust steam turbines as applied to plants where large amounts of the latter are freely available. The article is of interest as it shows that although the initial cost of a live steam plant is about 40 per cent below that of mixed live and exhaust steam installations, the saving with the latter is, under the conditions specified, so great that the difference in the initial cost may be recovered in two or three years.

Under Thermodynamics is reported a discussion of what the author terms a thermodynamic paradox, a case where apparently more heat is recovered than is actually put in in coal at the generating end of the plant. As a matter of fact, Lord Kelvin, many years ago, predicted its possibility on theoretical grounds.

An investigation of fusible tin boiler plugs is reported from a paper published by the American Chemical Society. The outstanding points of the investigation are that unless the fusible plug is properly made, it may become a source of danger instead of being an element of safety. It was further found that pure Banca tin was not and is not being used in the filling of a considerable number of plugs on the market, but while no change would be detected in samples of pure tin under certain conditions of treatment, when lead was present, the filling, with same treatment would become porous at a comparatively low temperature, while in other cases tin oxide formed, having a higher temperature than the steel of the boiler plates themselves. From this investigation it appears, therefore, on the whole, that the purity of the metal used in the filling ought to be given much more attention than has been the practice hitherto.

A phenomenon known as a "hydraulic jump" is discussed in a paper before the American Society of Civil Engineers. The author discusses mathematically the relation between the depth, head and maximum discharge of controlling sections and indicates the nature of the hydraulic jump and the conditions under which it originates.

Several papers are reported from preliminary publications to the meeting at Atlantic City of September 28 to 30, 1915. Methods of reclamation of magnalium from turnings were discussed by John Caulson. S. Trood presented a paper on sherardizing, in which he investigates the process of sherardizing from the point of view of ionic relations between vapors of metals present in the sherardizing drum and shows the great influence of pressure in the drum, uniformity of zinc dust and heat and quality of iron. The paper is of considerable practical value and throws a good deal of light on this still somewhat incompletely understood process. The manufacture and use of alloy of vanadium and aluminum is discussed by W. W. Clark. It is shown that the alloy can be easily made, but that its field of application is rather limited. S. W. Parr gives the chemical composition of an acid resisting alloy. Its acid resisting properties appear to have been fully established, but methods of casting seem to still require further developments.

Two papers on asphaltic and bitulithic pavements are reported from the Journal of the Association of Engineering Societies. In connection with one of these papers is reproduced a table giving a summary of cost data for various kinds of pavements (collected in the State of Oregon).

In an abstract from a paper before the British Association are given some data on testing tool steels and in particular on a dynamometer used for such tests.

James J. Guest, in a paper abstracted in the Journal of the Institute of Mechanical Engineers, gives an interesting presentation of the theory of grinding, with reference to the selection of speeds in plain and internal work. From the same source has been made an abstract of a paper by H. Mowson on struts and tie rods in motion, of interest because it shows that formulae which have been derived for forces in stationary struts are only special cases of those obtained for rods in motion. Among other things, the author discusses in detail the case of a particular locomotive coupling rod which broke while in service and shows that the stress in the rod increases very rapidly as the speed of the engine increases, and that at very high speeds an increase of steam pressure does not appear to have as disastrous an effect as an increase of speed.

In a paper on safety valves before the Scientific Society of the Royal Technical College, Glasgow, D. MacNichol reports on the work which was done by the British builders on the design of safety valves for oil fuel vessels. It is of interest to point out in this connection that (The Journal, August 1915, p. 481), the German manufacturers, who like-

wise use a formula (the Caro equation) derived from coal burning boilers, found that their formula did not take care of the generation of steam in oil burning plants.

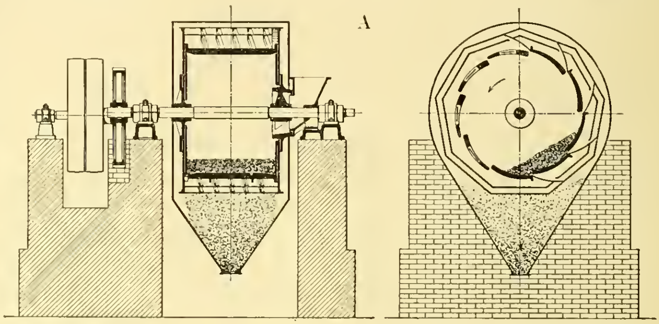
Those who are interested in the utilization of solar energy are referred to the brief abstract of a paper on this subject by A. S. E. Ackerman before the Society of Engineers (London).

## FOREIGN REVIEW

### Firing

Powdered Coal Preparation and Firing in Germany.

In modern German plants for the preparation of powdered coal for firing in furnaces, the following is the accepted fundamental principle: simplicity of machinery and apparatus used, and accessibility of the whole arrangement. The operation, which must be entirely automatic, must be carried out by as small an amount of reliable machinery as possible, so that it can be operated without trouble by unskilled labor. The



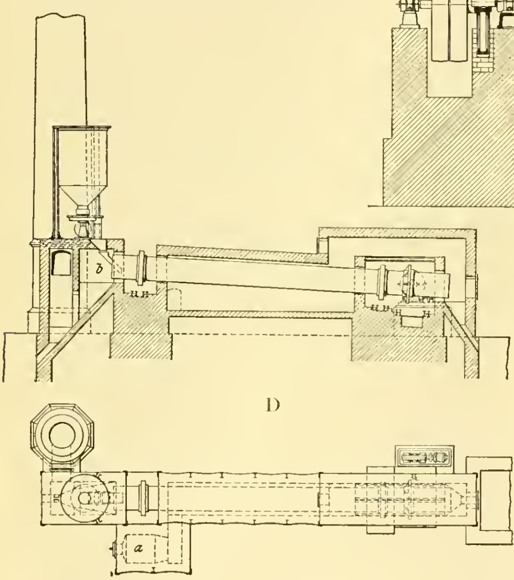




Fig. 1 *A*, Cementor Coal Crushing Mill; *D*, Polysius Drying Drum

path of the material should be as short as possible and as close as possible to a straight line.

In German plants particular attention is directed to simplicity of construction of the grinder, in which respect the German construction differs materially from American, and even though some typical American crushers,—e.g., the Fuller-Lehigh,—have been adopted in some German plants, as a rule they have not found ready application in that country, and for the same reason, the high speed machinery of this type built in Germany itself has not been much used.

Where the plants using powdered coal have efficient repair shops and skilled mechanics available, oscillating crushers and similar apparatus can be used without much difficulty and with certain advantages; otherwise, however, the saving effected by their use will be more than eaten up by interruptions in the operation of the plant.

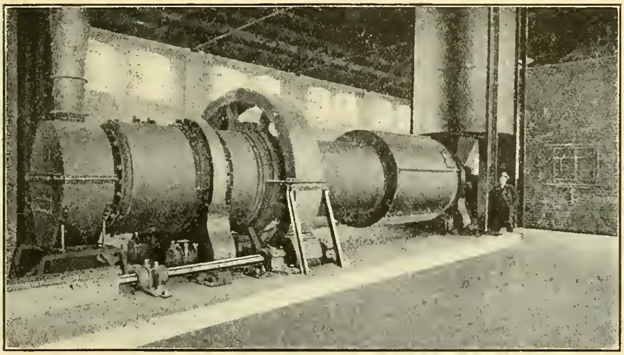
In the modern German plant nearly everywhere one finds slow running grinders with a large area of crushing, mainly of the ball and tube mill type. The larger amount of power consumption as compared with high speed machinery does not particularly matter here. Ball and tube mills are as a rule located one over the other, so that the grist produced by the ball mill can go directly to the tube mill and be converted into fine powder.

In order to improve the screening action, several types of ball mills have been placed on the market; for example, the so-called Cementor mill of Polysius, Dessau, Germany. Contrary to the usual practice in ball mills, this construction has unperforated crushing plates, these plates being located between the walls in such a manner as to form stages with each other. With this construction, the grist is forced to run through the entire path of the grinding, passes over the sieve and is then partly returned in a uniform manner into the grinding drum. Fig. 1A indicates diagrammatically the fundamental principle of this design, while Fig. B shows the combination of a Cementor mill and a tube mill.

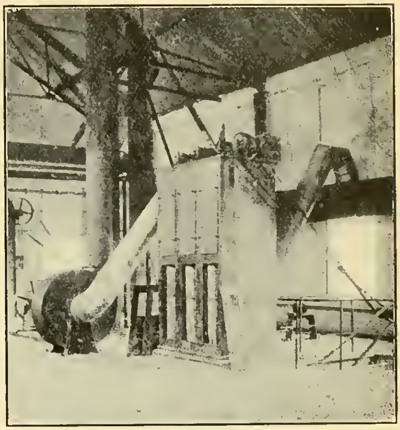
The high cost of foundations which such an arrangement involves, and the effort to simplify still more the grinding, led to the design of a machine which could carry out the crushing and fine grinding in one continuous series of operation. This resulted in the design of a combined crusher and grinder, forming one cylinder, a design particularly adapted for use in steel mills because of its extraordinary simplicity. This type of machine, called "Solo" mill, is likewise built in Germany by G. Polysius, Dessau (Fig. C), and consists of a seamlessly welded sheet cylinder running in circular bearings. This cylinder is divided by a wall into two chambers, one the crushing chamber with hard steel plates and steel balls, and the other the fine grinding chamber with Silex lining and quartz stones. The crushing chamber is surrounded with screens, and is enclosed in a sheet steel jacket, and can crush pieces as large as a man's fist. This grist then falls through slots at the end of the crushing chamber upon screens over which it travels, just as in the Cementor, to the admission side of the grinding mill. What remains over the screen is carried back into the crushing chamber while that which passes through the screen is delivered to the grinding chamber and handled there.

As compared with the oscillating and Fuller mills, this design has the advantage of handling pieces to the size of

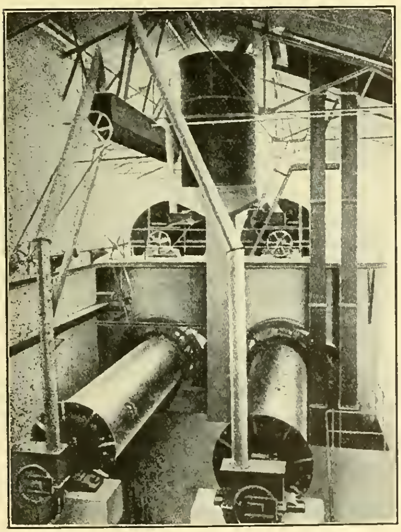
a man's fist; as compared with mills which require special separators, as in the Raymond crusher, there is the advantage that the Solo mill uses no cyclones, etc. In addition to that, there is the very important consideration that this type of mill insures to a very large extent against the occurrence of fires and explosions where the material handled has to be transferred from one apparatus to another, it is very difficult to provide against its escape and the formation of inflammable or explosive mixtures with air. In this case, as shown in Fig. D. The hot gases from the grate *a* play around the drum and pass through the interior of it and dust chamber *b*, into the smoke stack or the exhaustor, as the case may be. The gases when they reach the interior of the drum have so low a temperature that no gasification of the coal can take place. With very fine coal, special arrangements are provided to prevent the dust being carried away with the gases. The dimensions of the dust chamber are selected in accoradnce with the kind of coal to be dried.



C



G



B

E

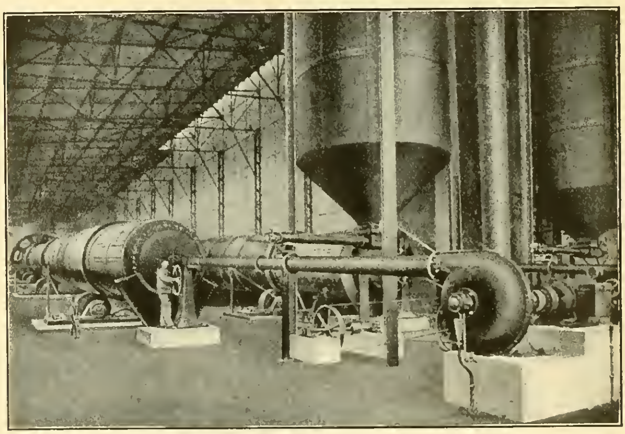


FIG. 1 *B*, COMBINATION OF CEMENTOR MILL AND TUBE MILL; *C*, SOLO MILL; *E*, COAL HEATING; *G*, SUCTION DUST FILTER

this source of danger is eliminated to a large extent, and the author states that explosions have never occurred in mills of the Polysius type. The objection is often made to crushers operated with screens on account of their rapid wear; in the Solo mill these screens consist of perforated steel sheets of high resistance, in addition to which the construction is such that large pieces of iron that cause most of the wear cannot reach the screen.

As a rule, the Polysius Company build their drying drums The brickwork is sometimes laid funnel-shaped at the bottom, so as to allow the dust settling on the walls, to fall into the container below. The drum may also be very conveniently heated by blast furnace or coke oven gases. The system of heating proper, as shown in Fig. E, is derived from that used in America.

Double worms are provided for carrying the coal dust from the storage bins, the windings of the two worm spirals being staggered with respect to one another, which ensures

a uniform supply of coal dust. The speed of rotation of the conveyor is adjustable by means of the Polysius governor (not shown in detail), which can be made to act simultaneously on the throttle in the air supply so as to vary the amount of blast in proportion to the increase and decrease of the coal dust handled. A special indicator is also provided, permitting the reading of the amount of coal dust used. The suction piping of the high pressure fan is connected with the cooling drum or such device as is used for conveying the sintered or roasted material; it delivers air of combustion preheated to from 300 to 400 deg. cent. (572 to 752 deg. fahr.). One part of this air is taken in by suction through the exhaustor, while the rest goes through the smoke stack. In rotary cement kilns, an excess of air is usually admitted and the amount of air is governed by a throttle located at the smoke stack.

by means of a suction fan. Similar filters have been recently introduced in iron plants to clean blast furnace gases. The author points out that the use of such devices for cleaning air and the protection of workmen considerably increase the cost of installation of German plants as compared with American plants, which fact, however, ought not to be weighed against the safety of the workmen and their improved state of health. (*Neuerungen in Kohlenstaubfeuerungen, Stahl und Eisen*, vol. 35, no. 38, p. 965, September 23, 1915, 6 pp., 9 figs. *d.*)

**Internal Combustion Engines**

Processes of Combustion in a Hot Bulb Engine, Erich Weisshaar.

Experimental and theoretical investigation of the processes of combustion in a hot bulb engine.

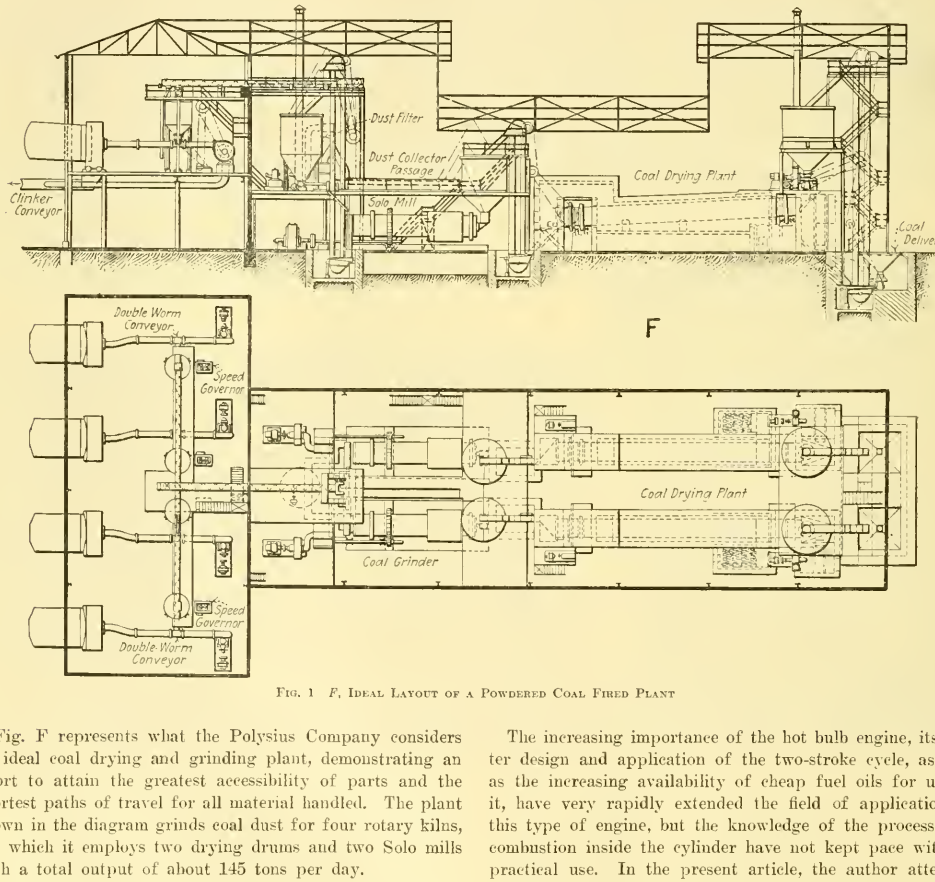



Fig. 1 *F*, Ideal Layout of a Powdered Coal Fired Plant

Fig. F represents what the Polysius Company considers an ideal coal drying and grinding plant, demonstrating an effort to attain the greatest accessibility of parts and the shortest paths of travel for all material handled. The plant shown in the diagram grinds coal dust for four rotary kilns, for which it employs two drying drums and two Solo mills with a total output of about 145 tons per day.

German law prescribes the installation of efficient air cleaning apparatus for the protection of the health of workmen. The suction dust filter used in the described plant is shown in Fig. G. The air, with such dust as it may contain, is taken from all the machines of the coal grinding mill, and driven through a center passage and then through the filter

The increasing importance of the hot bulb engine, its better design and application of the two-stroke cycle, as well as the increasing availability of cheap fuel oils for use in it, have very rapidly extended the field of application of this type of engine, but the knowledge of the processes of combustion inside the cylinder have not kept pace with its practical use. In the present article, the author attempts to answer the question as to how this most important process, that of combustion, occurs in a hot bulb engine.

The engine investigated was a stock type of 2-cylinder crude oil marine engine of the Maschinenbau A.-G. vormals Ph. Swiderski, adapted for land use by reduction of the speed of rotation. It was loaded very uniformly by a drive

to a centrifugal pump, and was fed with tar oil and some gas oil. Only very little water had to be injected. The amount of tar oil and water was regulated by a governor, while the addition of gas oil remained constant. The engine had the following dimensions:

Cylinder 1
- Diameter....................322 mm (12.67 in.)
- Stroke........................381 mm (14.99 in.)

Cylinder 2
- Diameter....................320 mm (12.59 in.)
- Stroke........................379 mm (14.91 in.)

The opening of the exhaust port begins at 0.72 of the piston stroke: average speed of rotation, 261 r.p.m.

The diagrams show quite material oscillations in the expansion line which were equalized by placing above and below the oscillation, enveloping curves and plotting an average curve between these two. Such a method is permissible because it may be assumed that we have to deal here with damp free oscillations. Four diagram sets of ten 2-strokes each, were carefully measured for each cylinder and all

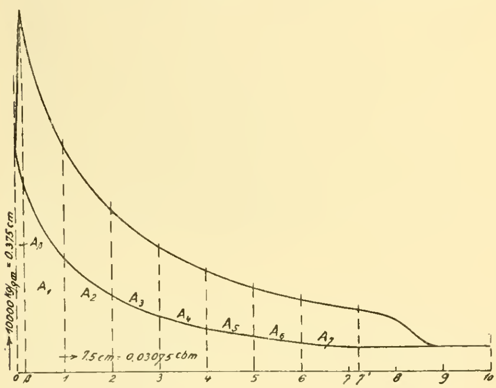



FIG. 2 AVERAGE DIAGRAM OF PROCESSES IN A HOT BULB ENGINE

combined, on an enlarged scale, into a single average diagram, Fig. 2. The maximum pressure could not be determined with certainty from the enveloping curves, and it was plotted in such a manner that the corresponding point on the heat diagram would not have an impossible location. The average diagram shows an average pressure of 2.27 kg. per ccm. (32.28 lb. per sq. in.), so that the indicated output amounts to 81 h.p. Since the efficiency of the pump and its ability were known only approximately, the effective output could only be estimated, and was taken to be 60 h.p.

The author discusses in detail the process of combustion, in the following manner:

When the piston is at the upper dead center, there is contained in the compressed mixture of exhaust gases and air a quantity of heat $J_o$. To this has to be added the quantity of heat, $Q$, contained in the oil and becoming free on combustion. At the point 7′, when the exhaust port is open, there is contained in the gas a quantity of heat $J_7$. On the way from the dead point to the opening of the slot, there is delivered a quantity of work, $A$, represented by the area between the ordinates $O$ and $7^1$ on one hand and the expansion

TABLE I NUMERICAL DATA TO FIG. 1

| Ordinates | Stress in kg./qm. (1 kg./qm. = 0.00142 lb. per sq. in.) | Volumes in cbm. 1 cbm. = 35.314 cub. ft.) | Gas constant | Absolute temperature (deg. cent.) | Heat transmission in WE/gm.hr. (1 WE/qm.hr. = 0.37 B.t.u. per sq. ft. per hr.) | Area in qm. (1 qm. = 10.7 sq. ft.) | WE per hr. (1 WE = 3.968 B.t.u. |
|---|---|---|---|---|---|---|---|
| | $p$ | $V$ | $R$ | $T$ | $W$ | $F$ | $F W$ |
| 0 | 95,500 | 0.00633 | 29.20 | 918 | 51,000 | 0.1965 | 10,020 |
| β | 154,000 | 0.00664 | 29.00 | 1,518 | 271,000 | 0.2003 | 54,300 |
| 1 | 96,000 | 0.00942 | 29.00 | 1,341 | 177,000 | 0.2349 | 41,600 |
| 2 | 69,200 | 0.01248 | 29.00 | 1,281 | 151,000 | 0.2733 | 41,300 |
| 3 | 53,050 | 0.01556 | 28.90 | 1,230 | 131,500 | 0.3117 | 41,100 |
| 4 | 42,850 | 0.01863 | 28.90 | 1,189 | 118,000 | 0.3502 | 41,300 |
| 5 | 35,700 | 0.02171 | 28.80 | 1,160 | 108,000 | 0.3885 | 42,000 |
| 6 | 30,600 | 0.02478 | 28.80 | 1,133 | 100,000 | 0.4270 | 42,700 |
| 7 | 26,200 | 0.02850 | 28.80 | 1,116 | 95,000 | 0.4733 | 45,000 |

and zero lines on the other hand (This work is expressed here in calories).

On the other hand, because of cooling during the same period of the motion of the piston, there is a loss through cooling of quantity of heat $q_w$, to which has to be added the heat loss $q_r$, due to the fact that a part of the oil is taken out by the exhaust, incompletely burned, in the form of carbon monoxide and incandescent soot. Since there must be an equilibrium between the quantities of heat added and taken out:

$$J_o + Q = J_7 + A + Q_w + Q_r$$

in this equation $J_o$ and $J_7$ can be determined from the gas temperatures $T_o$ and $T_7$, provided the weight of gas $G$ in the cylinder is known (The specific weight of gas is here assumed to be variable).

For the determination of heat losses, $q_w$, due to cooling, the author uses an expression which he previously derived for the case of a Diesel engine. The determination of the weight of gas present in the cylinder during the comparison and expansion is a rather difficult experimental proposition (*Der Verlauf der Verbrennung im Glühhaubenmotor*, Erich Weisshaar, *Der Oelmotor,* vol. 6, no. 5, p. 151, August 1915, 6 pp., 4 figs., *et*).

### Steam Engineering

1250 KW MIXED PRESSURE TURBO-GENERATOR, F. Schulte

Description of a mixed pressure turbo-generator and calculations showing the commercial advantages and disadvantages of live steam and exhaust steam turbines under certain predetermined conditions.

In this instance, there was an electric generating plant at one of the two mines of the same company, but with the growth of business, its output ceased to be sufficient. There was available at the plant approximately 11,000 kg. (24,200 lb.) of exhaust steam per hour, and at a consumption of 16 kg. (35.2 lb.) per kw-hr., approximately 700 kw. could be obtained from this source. About 1000 kw. were considered necessary; hence, about 300 kw. would have to be generated by live steam if a mixed pressure turbine were used. It is clear that the selection of type of turbine was to be determined principally by economic considerations.

An investigation showed that the first cost of pure live steam turbines, with equipment and buildings, would be

155,000 marks (roughly $38,000) in addition to which another boiler plant, costing 49,500 marks would have to be installed, thus bringing up the first cost to about 204,500 marks.

A mixed pressure turbine, with all its equipment and buildings, would cost 255,000 marks, or about 50,000 marks more than a live steam turbine and the additional boiler plant. On the other hand, the operating costs, under the assumption that the turbine would run 16 hours per day, under full load, and that during this time there would be available 700 kw. exhaust steam, would be as follows:

| *A—Live Steam Turbine* | Marks |
|---|---|
| 1. Interest and depreciation on first cost at the rate of 10 per cent | 20,470 |
| 2. Attendance, 16 hr. per day and 300 working days per year | 1,920 |
| 3. Cost of live steam, 16 hr. per day, 300 days per year, with steam consumption of 9 kg. (19.8 lb.) per kw-hr. (under the assumption that 1000 kg. would cost 160 marks) | 69,120 |
| 4. Lubricating oil | 490 |
| 5. Repairs | 1,400 |
| 6. Cost of attendance on the three additional boilers | 2,800 |
| Total operating cost | 96,200 |

| *B—Exhaust Steam Turbine* | Marks |
|---|---|
| 1. Interest and depreciation of plant at the rate of 10 per cent | 25,500 |
| 2. Attendance, 16 hr. per day, 300 working days per year | 1,920 |
| 3. Cost of live steam for 300 kw., 16 hr. per day, 300 days per year (under the assumption of 9.5 kg. per kw-hr.) | 21,880 |
| 4. Lubricating oil | 500 |
| 5. Repairs | 1,000 |
| Total operating cost | 50,800 |

Which shows that the operating cost of a live steam turbine is approximately 45,400 marks per year higher than the cost of the exhaust steam turbine. Actually, however, the saving in operating expenses with the exhaust steam turbine will be considerably lower, partly because some of the exhaust steam would be utilized for the preheating of feed water and partly because the exhaust steam from the hoisting engines is available at irregular intervals and may thus to a certain extent have to be exhausted into the atmosphere.

The paper describes in detail the construction of the turbine condensing plant and steam accumulator and gives as well data of tests with pure live steam and pure exhaust steam as driving media. Tests have shown that the steam consumption either way was below the guaranteed amount and that the expectations from the economic point of view were satisfactorily fulfilled. A striking indication of the saving through utilization of the exhaust steam is given in the fact that before the installation of the turbine, about 3000 to 4000 marks ($750 to $1000) worth of current was purchased from outside sources, while after the turbine has been installed, not only has this entire amount been saved, but an opportunity for a source of profit of about 3000 marks ($750) from the sale of current was opened, while the steam consumption of the mine remained at the former level. (*Mischdruck-Turbogenerator für 1250 kw. der Zeche Neu-Iserlohn I der Harpener Bergbau-Akt. Ges.*, F. Schulte, *Zeits. des Vereines deutscher Ingenieure*, vol. 59, no. 39, p. 785, September 25, 1915, 6 pp., 6 figs., *dp.*)

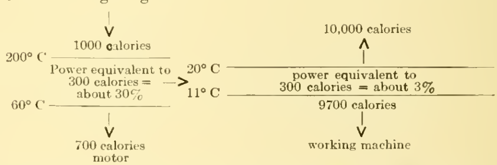
## Thermodynamics

### A Thermodynamic Paradox.

The paradox which the author considers, exists in the fact that under certain conditions, the total amount of heat developed in machinery from a pound of coal, appears to be larger than that initially contained in the coal. The possibility of this was first pointed out by Professor Thompson (Lord Kelvin) and since utilized in the refrigerating system of Altenkirch (see the Journal, October 1913, p. 1574).

The author questions whether a refrigerating machine can be used as a heat generator, apart from the consideration of its output of cold, and shows that if this be done, apparently an excess of heat is produced. The whole point lies in the fact that refrigerating machinery may produce not only cold in the evaporator, but also heat in the condenser. If the heat generation be considered the main purpose of such a machine, then, with a small temperature difference, an amount of heat could be made available in excess of that consumed in the motor driving it. The situation is as if the power transferred to the refrigerating machine had the properties of a ferment. The output of cold and heat is not equivalent to this power, the latter giving simply the impetus of an incomparably greater heat transformation.

In two mechanically connected cycle processes, a large temperature difference with a small amount of heat in the first process, creates a large output of heat with a small temperature difference in the second process, in accordance with the following diagram:




There is no doubt, of course, that the heat generated in the compressor is equivalent to the amount of power consumed. Hence this amount of heat is small, but when steam is liquefied at a higher temperature, a large amount of latent heat is freed (the amount which was tied up at the lower temperature in the evaporator) and it is this amount of heat which is of determining influence. As an example, the author gives the following particular case:

A good steam engine requires 0.75 kg. (1.6 lb.) of coal per effective h.p-hr. One h.p-hr. is equivalent to 637 calories. If one takes the heating value of coal to be 5600 calories (10,800 B.t.u. per lb.), then 4200 calories have been used up and the utilization of heat may be taken to be only 15 per cent. An ice making machine has been tested in this respect, and produced at 14.75 effective h.p. in the condenser, 7250 calories per hr., or 4915 calories per effective h.p-hr., so that with all losses, there has been actually obtained with an expenditure of 4200 calories, an output of 4900 calories (with a Diesel engine, 4900 calories can be obtained with an expenditure of only 2200 calories).

(Of course the above does not really conflict with the accepted laws of the mechanical theory of heat, as has been

previously shown by Lord Kelvin. Editor's note) (*Ein "Paradoxon" aus der mechanischen Wärmetheorie,* Johs. A. F. Engel, *Dinglers polytechnisches Journal,* vol. 330, no. 15, p. 289, July 24, 1915, 2 pp., *t.*)

### Miscellanea

LAWS OF DETERIORATION OF TELEGRAPH POLES, Fr. Moll.

The paper discusses the laws of deterioration of wooden poles used for the suspension of electric wires, in particular, telegraph poles. The author points out that the entire matter of impregnation engineering is still in its initial stages of development, and the subject of the efficiency of impregnating materials has been investigated only to a limited extent.

The main question in this connection is, what is the relation between the chemical constituents of the impregnating materials and their efficiency as inhibitors of decay. The work of Netzsch has shown, for the group of salts of fluorine, that salts in the solution of which free ions of fluorine are developed, have an efficiency practically proportional to the contents of fluorine in the salt. The present writer has established a similar relation for a number of salts of zinc with regard to the contents of zinc metal, and it appears, therefore, that the inhibiting action is dependent either upon the presence of acid ions or metal ions. If, however, both are at work, the investigation becomes much more difficult and more extensive experimentation is required in order to establish the law of inhibitory action. It may here be mentioned that most of the so-called "data of tests" published as advertising matter by various manufacturers of impregnating materials can be considered as entirely worthless in this connection.

In the absence of sufficient reliable data on the efficiency of impregnating materials, the best source of information appears to be statistical data on the life of various types of telegraph poles. In Germany such data have been collected since 1850 and published at various periods, in particular, by Christiani in 1905. These data have shown that of all of the processes of impregnation those using kyanization and impregnation with tar oil, have given the best results. The economic value of impregnating poles may be determined in accordance with the following formula:

$$\text{Economic efficiency} = \text{average cost per annum} = \frac{\text{cost of operation}}{\text{average life.}}$$

The cost of operation includes of course both the impregnation and the delivery of the poles to the spot, and is, as a rule, given by the accepted bids, but the average life of the pole is, to a greater or less degree, an unknown quantity. Some data are given in the German publication, *Archiv für Post und Telegraphie,* 1913, p. 229, where the life of poles of various kinds of wood, with and without impregnation, is given as compiled from data published by telegraph administrations all over the world. From this publication the writer cites Table 2.

On the whole, the author comes to the conclusion that the life of impregnated poles may be predetermined by the application of the usual laws of probability and that the destruction of wooden poles through decay follows the usual probability curve. He gives for it the following equation:

$$y = \frac{0.564h}{e^{h^2 x^2}}$$

in which $x$ and $y$ are, as usual, unknown quantities, $e$ is the basis of natural logarithms, $h$, a constant which may be denoted as a parameter and has a different value for each average period of life of the post; for any average life of post, $h$ may be expressed in the following manner:

$$h = \frac{0.477 \times 5}{\text{average life}}$$

Thus, for the average life of 20 years, which is about what is obtained from kyanization, and poles impregnated in a

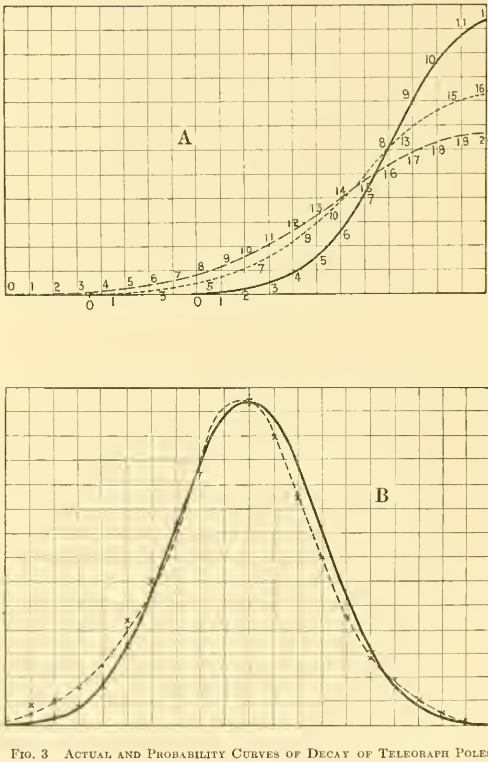



FIG. 3 ACTUAL AND PROBABILITY CURVES OF DECAY OF TELEGRAPH POLES

proper manner with tar oil, the curve of probable exchange of poles has the following shape:

$$y = \frac{0.564 \times 0.096}{e^{0.096^2 \times x^2}} = \frac{0.0541}{e^{0.00012 \times x^2}}$$

The author gives the following two curves: curve 3*A* indicating the average line of necessary exchange derived from 40 statistical compilations. This curve was recomputed on the basis of an average life of ten years. One division on the abscissa line corresponds to one year in the statistical data and the total length of the abscissae is 20 years; the

ordinates indicate the approximate amounts of exchange of poles in the years given by the abscissae, one division of the ordinates giving one per cent of the total number of poles. For purposes of comparison there is drawn in full lines over the curve of actual exchanges, the curve of probability.

Fig. B gives the curve of probability for a value of $h$, corresponding to an average life of twelve years, 16.5 years and 20 years. Only the left part of the symmetrical curve is drawn. In the abscissae, one division corresponds to one year of life in the ordinates, which division corresponds to 1 per cent of the total number of poles. The ordinates give, therefore, the accepted approximate yearly exchange of poles. (*Die Gesetzmässigkeiten im Abfall hölzerner Maste für elektrische Leitungen,* Dr.-Ing. Friedrich Moll, *Elektrotechnische Zeitschrift,* vol. 36, no. 35, p. 449, September 2, 1915, 2 pp., 2 figs. *st*).

TABLE 2 AVERAGE LIFE OF TELEGRAPH POLES OF VARIOUS WOODS

| *Untreated* | *Years* |
|---|---|
| Oak (Hungarian) | 7 |
| Cypress | 8 to 10 |
| Larch (Austrian) | 10 |
| Chestnut | 10 |
| Cedar (N. America) | 15 |

# ENGINEERING SOCIETIES

## AMERICAN CHEMICAL SOCIETY

*Journal of Industrial and Enginering Chemistry, vol. 7, no. 10, October 1915, New York City.*

An Investigation of Fusible Tin Boiler Plugs, G. K. Burgess and P. D. Merica.

The investigation was prompted by the explosion on May 11, 1914, of a boiler on the steamship *Jefferson,* which subsequent investigation showed to have been due to low water and consequent overheating of the boiler plates. This should have been indicated by the fusion of the filling of the tin fusible plug in that region, but the plug was found to be unmelted and superficially sound. When the plug was sent to the Bureau of Standards for investigation and there was sawed open longitudinally, it was found to contain only traces of the original tin imbedded in a dirty greenish matrix consisting largely of tin oxide. This oxide has a melting point of about 2900 deg. fahr., and it was distributed in such a form and quantity that it held the pressure of the boiler. As a matter of fact, instead of being an easily fusible material, it would not have melted until the bronze of the casing and even the steel of the boiler had melted, and instead of being a factor of safety, it was a menace.

As no data as to the worth of fusible tin plugs of this sort were found in technical literature, the steamboat inspectors were requested to send in to the Bureau more plugs for testing purposes and in answer to the request, about 250 plugs were received, of which about 100 had been in service varying from four to twelve months. These plugs represented the products of some 105 firms.

The plugs were classified according to the degrees of deterioration. Some were found to be partially melted away; others with fillings expanded in service, corroded or pressed in at the water side. In some plugs, non-metallic formations or incrustations were found in the filling, such as zinc oxide or copper oxide. It appears practically certain that this oxidation occurred in service and that the oxide was not poured in with the tin generally. In order to determine the relation between the temperature values found and the purity of the tin in the fillings, the melting points of a number of the old plugs, as well as new ones, were taken and chemical analyses made of the fillings showing abnormal melting points. It was found that Banca tin was not and is not being used in the filling of a considerable number of plugs. Of 35 plugs analyzed chemically, only six fillings showed 0.20 per cent or less impurities, or only six out of the 35 were composed of any variety of high grade tin. The principal impurities were lead or zinc. Of about 70 melting point determinations made on used and new plugs, only eleven gave values within 0.5 deg. cent. of the melting point of pure Banca or Straights tin.

Plugs with fillings that had a low melting point and contained zinc, showed what the author calls " network " type of oxidation, which he explains by the constitution of the zinc-tin alloy and its behavior on cooling. In the zinc-tin alloy of certain particular types, the tin crystals are surrounded by an envelope of zinc. If this alloy be brought in contact with a corrosive aqueous solution, the latter will attack the zinc first, eating its way into the plug through the grain or crystal interstices, and the tin filling finally becomes honeycombed in structure. The corrosion of the tin itself may start from these crystalline canals and the oxidation produced remain, forming gradually the oxide network structure already referred to. Alkaline waters, such as would be produced by over addition of soda boiler-water softener, attack zinc even at ordinary temperatures and probably corrode tin at high temperatures. The temperature of the water and plug will determine to a greater extent the rapidity of the progress made by the oxidation.

A number of new plugs, as well as plugs made up at the Bureau, containing definite amounts of impurities, were subjected to the action of water at high temperatures to determine what would be their behavior under these known conditions. For this purpose, the plugs were put in a copper autoclave and heated for various periods at a temperature of from 180 to 195 deg. cent. in either tap or distilled water. Of 14 new plugs, heated for 195 hours and 20 new plugs for 140 hours in tap water, only three showed any change whatever. These were all from one manufacturer and contained lead in varying amounts. All were somewhat distorted and covered with spongy abrasions. Whereas no lead could be detected in the microstructure before heating, after heating the lead had coalesced as an enveloping boundary to the tin crystals.

The plugs containing zinc and lead in amounts equal to or above 0.5 per cent were generally found cracked after heating for about 500 hours at from 350 to 380 deg. fahr. In some cases, particularly when lead was present, the filling had become porous due to the melting out of the low melting eutectoid, which in this case melts around 170 deg. cent. (330 deg. fahr.). *No change could be detected in the samples of Banca or Straights tin caused by this treatment, other than a slight surface oxidation.*

The article discusses briefly the testing of the purity of zinc. The most important conclusion to which the author comes is that the use of *pure* tin would probably eliminate danger of oxidation of plugs in service (6 pp., 7 figs., *ep. A*).

## AMERICAN SOCIETY OF CIVIL ENGINEERS

*Proceedings, vol. 41, no. 7, September 1915, New York City*

The Hydraulic Jump, in Open-Channel Flow at High Velocity, Karl R. Kennison (abstracted)
A Study of the Depth of Annual Evaporation from Lake Conchos, Mexico, Edwin Duryea and H. L. Haehl

### The Hydraulic Jump, in Open-Channel Flow at High Velocity, Karl R. Kennison

When water is discharged into a flume through a contracted gateway and under a considerable head it sometimes continues to move in a thin sheet at a high velocity along the bottom of the flume for several hundred feet. Then it suddenly becomes turbulent and forms what is called a "hydraulic jump," the surface level down stream from this point being very much higher than that of the approaching high velocity discharge. Another case is when water flows over an ogee dam and out on a smooth apron; then it sometimes continues in a thin sheet having a surface level far below the normal level of the river until it suddenly changes into a tumbling mass rising to the normal river level by this hydraulic jump. This phenomenon is sometimes of great practical importance in connection with the design of dams; for example, in one case it was desirable that the back roll or hydraulic jump should not be allowed to extend far off down stream below the foot of the ogee, from a concrete apron which protected the clay river bed from scour. In another case, it was desirable that the hydraulic jump should not extend down stream so far as to interfere by its violent surges with the draft tube exits of a power house.

The author discusses mathematically the relation between depth, head and discharge and the maximum discharge of controlling sections. He comes to the following general conclusions:

In the case of water flowing in an open channel on a steep gradient there are certain controlling sections which throttle the flow and determine the quantity of the discharge. If the contraction which causes this throttling of the flow is sufficiently gradual, for example, a submerged dam with smooth gradual approach and getaway, it can be shown that the depth of water at this point is theoretically two-thirds of the total head measured from the channel bottom or dam crest up to the hydraulic gradient, and the discharge per foot of length should be 3.09 $H$ 3 ÷ 2.

At other points than at the controlling section, the depth of water is not necessarily determined by the quantity discharged and the available head, but also by the channel conditions. The upper stage is the normal level in an ordinary stream and for very low velocities is practically coincident with the hydraulic gradient. The lower stage is that ordinarily taken by water discharged at high velocity from an orifice or below a spillway dam. In other words, it can be shown that in any open channel, except at controlling sections, there is in addition to the existing water level another level at which the same quantity of water might be flowing with equal steadiness and under the same head or elevation of hydraulic gradient.

In the case of smooth, undisturbed flow the stream must stand at one of these two levels; that is, water flowing in a smooth channel of a uniform section must continue to flow at its existing stage, whichever one that happens to be, until for some reason it encounters a controlling section where the two alternative stages merge into one and the depth is two-thirds of the total head. Below this controlling section, the two possible stages again separate. At such a point as this, the water level may change without disturbance or interruption of the steady flow from one stage to another, or may continue in the same stage. Thus the water behind the spillway dam is approaching at the upper stage and just below the dam it flows away at the lower stage. The change occurs smoothly over the dam where the two stages are merged into one, but if the dam is submerged by back water almost as high as the up-stream pool, the surface may simply dip down locally at the dam where the depth is two-thirds of the head. In such a case the upper alternative stage is maintained throughout, below as well as above the dam. Usually the presence of the controlling section tends to conceal the existence of the two alternative stages, but water flowing at the lower high velocity stage and suddenly encountering obstructions which tend to destroy its velocity, may rise suddenly, and with considerable disturbance and eddying, to the more stable upper low velocity stage, thus forming what is known as the hydraulic jump.

The only energy lost in this phenomenon is that used by accompanying disturbance and eddying, as the jump proper merely converts kinetic into potential energy. Ordinarily, however, when appearing below a spillway dam, the hydraulic jump is accompanied by such violent disturbance and eddying that the total surplus energy in the water may be destroyed in this way (15 pp., 13 figs., *mA*).

## AMERICAN INSTITUTE OF METALS

*Preliminary publication of papers read at the meeting at Atlantic City, September 28 to 30, 1915*

The Development of an Acid-Resisting Alloy, S. W. Parr (abstracted)
A Preliminary Report on Molding Sand, C. P. Karr
Effect of Changes in the Composition of Alloys Used by the American Railways for Car Journal Bearings, G. H. Clamer
Aluminum Bronze Alloys, W. M. Corse
The Alloys of Chromium, Copper and Nickel, David F. McFarland and Oscar E. Harder
The Effects of the Common Impurities in Spelter upon Slush Castings, Gilbert Rigg and Henry C. Morse
The Manufacture and Use of Alumino-Vanadium, W. W. Clark (abstracted)
Sherardizing, S. Trood (abstracted)
Reclamation of Magnalium from Turnings, John Coulson (abstracted)

### Reclamation of Magnalium from Turnings, John Coulson

The use of magnalium metal (an alloy of aluminum and magnesium) for finished castings has increased to such an extent that the recovery of the metal from the turnings has become an important factor. The difficulty of the operation consists in the fact that the oxidation of finely divided magnalium is extremely rapid, and, unless some process of agitating the melted material is applied, the oxide film will prevent it from fusing together.

Fluxes composed of chlorides and fluorides of the alkaline earths have been used with some success, as well as cryolite. The latter, however, is objectionable, since it attacks silicon and graphite crucibles. To avoid the difficulties involved in the use of the various fluxes, a method has been developed of using inert gases; hydrogen has been found to give the best result. As a fluxing agent common salt was used. The turnings were boiled for a few minutes in a 4 per cent salt

solution, which was then poured off and took with it the objectionable scum. The gas pressure was applied through a pipe overhead. It was even found that the turnings could be melted in an open crucible after they had been boiled in a solution of slightly fluxing salt. The damp turnings were turned into a crucible heated to 900 deg. Cent., and by mechanical means were forced to coalesce as they melted, each addition of turnings being thoroughly puddled until the mass became uniformly viscous. After the last puddling operation, the charge was left standing in the hot crucible for ten or fifteen minutes which gave the oxide time to rise to the surface, where it was held while the clean metal was poured from underneath.

The metal recovered from the turnings contains some oxide and is therefore not as good as the original magnalium, but its physical characteristics can be improved by the introduction of a deoxidizing agent, e.g., 1 per cent of metallic calcium or ½ per cent of calcium aluminum silicide (7 pp., *d*).

Sherardizing, S. Trood

The paper presents an investigation of the process of sherardizing, an explanation of the usual lack of uniformity of results and directions for making the results uniform and for reducing the time required for the process. A brief history of the process is given in the introductory paragraphs.

The author shows that in the sherardizing drum there are microscopically small globules of zinc vapor surrounding the particles of zinc oxide and charged electrically. In addition to that, there are gases emanating from iron and also carrying ionic charges. Iron and zinc have different potentials. As a result, discharges must occur which, in their turn, precipitate solids from gases—that is, zinc and iron.

If that is so, the atmospheric pressure will have a considerable effect on the process as the vapor tension of the gas will vary with the pressure and the gases will be more readily given off in vacuum. To prove this, the author created a vacuum in a small sherardizing drum, and results were produced in ten minutes in a vacuum which would require six hours at the same temperature under atmospheric pressure. Since electric potential is higher for pure gases than for mixtures of gases, it is of advantage to have the zinc dust and iron in as pure a state as possible. The author comes to the conclusion, therefore, that uniformity of zinc dust, uniformity of heat, and the quality of iron are of great importance as affecting the uniformity of results. In addition to this, the proper time of sherardizing is an essential factor.

The best method of preparing the surface to be sherardized is shot air blasting. Sand blasting is not good because particles of sand penetrate the pores of the iron. Pickling requires great skill, and must be done very carefully, as often sulphates and phosphates are created on the surface and are hard to remove, in addition to which traces of salts, alkalies and acids after pickling may produce a retarding result when heated, so far as the ionic charges are concerned.

In the zinc dust, zinc should not be below 85 per cent, zinc oxide not below 8 per cent, and lead should be kept down to about 1.25 per cent.

Experiments have shown that when the percentage of lead is too high, lumpy deposits will appear on the plain sherardized surface. The zinc dust particles must be kept uniform in size. After deposit of the zinc begins, the thickness of the deposit depends solely upon the time. The coating which is being deposited when the temperature is going up is the most dense and durable. Next in quality will be the coating at uniform temperature, and the poorest when the temperature is going down (11 pp., *ep*).

The Manufacture and Use of Alumino-Vanadium, W. W. Clark

The paper discusses the manufacture and use of an aluminum-vanadium alloy intended for use as a carrier of vanadium in the non-ferrous alloys.

The alloy is manufactured in the following manner: Ingot aluminum is melted in a graphite crucible provided with top and bottom holes. The thermit mixture of vanadic oxide and granulated aluminum is then ignited on top of the molten metal. After it has all been reduced, the mass is stirred and the metal tapped. Aluminum-vanadium alloy can also be manufactured without difficulty in the electric furnace. The alloys are not pure as they contain a fraction of one per cent of iron in addition to small amounts of silicon and carbon.

There are several difficulties encountered in the use of aluminum-vanadium alloys. Aluminum in an alloy of copper and zinc, or copper, zinc and nickel, tends to make the metal brittle when rolled. If a metal is not perfectly deoxidized, aluminum oxide may be found enclosed. In drawing metal such as cupro-nickel, aluminum is objectionable, as the metal hardens too quickly. The author believes therefore that nickel and manganese alloys of vanadium may be more suitable. He also considers it very doubtful that small amounts of vanadium will increase the tensile strength of non-ferrous metals beyond that due to its powerful deoxidizing properties, and vanadium should not be used as a scavenger, as there are a number of as good and cheaper ones available. If, however, used with metal previously cleansed, vanadium in small amounts does increase the elongation (8 pp., *p*).

The Development of an Acid-Resisting Alloy, S. W. Parr

The paper discusses the development of an alloy which, in addition to being able to withstand the corrosive action of acids and gases, would be suitable for use where density, strength and working properties are essential, besides being considerably cheaper than platinum and available in larger amounts.

This latter condition necessitated the production of this material from base metals. After a considerable amount of experimentation, an alloy has been developed such that six discs made of it have shown no weighable loss after contact with 25 per cent nitric acid for twenty-four hours. The chemical composition of this alloy is rather complicated:

| | |
|---|---|
| Cu | 6.42 |
| Mn | 0.98 |
| Si | 1.04 |
| W | 2.13 |
| Ni | 60.65 |
| Al | 1.09 |
| Fe | 0.76 |
| Cr | 21.07 |
| Mo | 4.67 |
| Total | 98.81 |

It has been found, however, that each additional element lowers the melting point of the alloy, and reduces the tendency to form an open texture or coarsely crystallized structure.

The melting point of the alloy is approximately 1300 deg. cent. When thoroughly liquid, the alloy pours readily and fills the mold perfectly, but the freezing point is so quickly reached that feeding of the casting from risers to make up for shrinkage is practically impossible, while the shrinkage is so excessive that cracks and hollow spots are very difficult to avoid. The material works in a lathe about the same as tool steel. So far, the attempts to draw the alloy into wire and roll it into sheets have been only partially successful. The tensile strength of the cast metal is approximately 50,000 lb. per sq. in. (7 pp., 2 figs., *de*).

## ASSOCIATION OF ENGINEERING SOCIETIES

*Journal, vol. 55, no. 2/406, September 1915, St. Louis, Mo.*
Asphaltic and Bitulithic Pavements:
Cost of Raw Materials and Cost of Mixing, R. S. Dulin
Cost of Grading, Hauling, Spreading, Rolling, etc., R. G. McMullen (both abstracted)

### Asphaltic and Bitulithic Pavements: Cost of Raw Materials and Cost of Mixing, R. S. Dulin.

The paper presents cost data covering the items of raw material and mixing of asphaltic and bitulithic pavements, taken from data collected by the engineers of the city of Portland, Oregon. The unit prices used for the various ingredients in the pavement mixtures have been taken as the same for the same materials, no matter in which pavement they were used.

For various types of pavements, the author indicates the limiting proportions of the various ingredients and materials required by the specifications, as well as the mean of the various proportions actually used in the samples tested, and explains how the samples were taken. Table 3 gives a summary of the cost data for various pavements. This Table has been so arranged that pavements which are naturally competitive are placed consecutively. The comparative cost of the materials, for wearing surface, binder, base and entire pavement, are given for twelve different types of pavements (9 pp., *p*).

TABLE 3 SUMMARY COST OF DATA FOR PAVEMENTS.

Table of Cost of Materials per Square Yard of Finished Pavement.

| Types of Pavements | Specifications No. | Wearing surface 2 in. thick | Wearing surface 1½ in. thick | Binder 1 in. thick | Bituminous base 3 in. thick | Crushed rock base 4 in. thick | Crushed rock base 1½ in. thick | Concrete base 5 in. thick | Total cost of material per square yard of finished pavement |
|---|---|---|---|---|---|---|---|---|---|
| Asphaltic Concrete on Bituminous Base | 123 | $0.195 | ..... | ..... | $0.189 | ..... | ..... | ..... | $0.384 |
| Gravel Bitulithic on Bituminous Base | 132 | 0.171 | ..... | ..... | 0.189 | ..... | ..... | ..... | 0.360 |
| Asphaltic Concrete on Crushed Rock Base | 122 | ..... | $0.146 | $0.064 | ..... | $0.180 | ..... | ..... | 0.390 |
| Bitulithic on Crushed Rock Base | 131 | 0.171 | ..... | ..... | ..... | 0.180 | ..... | ..... | 0.351 |
| Asphaltic Concrete on Concrete Base | 121 | ..... | 0.146 | 0.064 | | ..... | ..... | $0.396 | 0.606 |
| Bitulithic on Concrete Base | 130 | 0.171 | ..... | ..... | ..... | ..... | ..... | 0.396 | 0.567 |
| Sheet Asphalt on Concrete Base | 120 | 0.235 | ..... | 0.064 | ..... | ..... | ..... | 0.396 | 0.695 |
| Asphaltic Concrete Redress | 124 | ..... | 0.146 | 0.064 | ..... | ..... | $0.089 | ..... | 0.229 |
| Bitulithic Redress | 133 | 0.171 | ..... | ..... | ..... | ..... | 0.089 | ..... | 0.260 |
| Concrete Pavement (1–2–4 mix.) | 104 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.690 |
| Hassam Class "B" | 105 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.604 |
| Hassam Class "A" | 105 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 0.709 |

### Asphaltic and Bitulithic Pavements: Cost of Grading, Hauling, Spreading, Rolling, etc., R. G. McMullen.

This paper, which has to be read in connection with the preceding one, covers the cost items of grading, making the road, hauling, scarifying, shaping, spreading, rolling, etc.

The cost of hauling is based on the ton basis, using auto trucks of five ton capacity (the cost of maintenance and operation of the trucks is given in detail). The writer states that a table of all detailed costs in cubic yards and square yards for the different Multnomah County roads has been drawn up and a copy has been filed with the Board of County Commissioners, so that it is now a public record and open to inspection; in the article, this table is not reproduced.

The total cost of laying a 6 in. concrete pavement has been found to be $1.05 per sq. yd. and the efficiency with which the building of concrete roads is now performed may be judged from the fact that of the total cost of the paving 70 per cent is the cost of materials, leaving 30 per cent, or a little over 30 cents per sq. yd. for the entire cost of labor, hauling of materials and the use of mechanical equipment on the job. In other words, the cost of raw material was $0.74, the cost of labor, $0.31, making a total of $1.05.

Ordinarily, the concrete pavement is 6 in. thick, while bituminous pavements are 2 in. thick, and the materials in the bituminous pavements are not so expensive as they are in the concrete pavement. The writer contends, therefore, that a 2 in. bituminous pavement can be laid for $0.60 per sq. yd., including overhead charges, etc., or an actual cost of $0.532. It must be remembered, however, that the above figures are not what the contractor's cost would be, but only the actual cost of laying the pavement and the question of "profits" (and also the cost of capital, etc., which the contractors have to take into consideration) has not been considered here.

Some of the speakers objected to the above figures as being too low, and pointed out several items which have been omitted, such as liability insurance, repairs to the plant, bond premiums, depreciation of the automobile trucks used in hauling materials, office expenses, plant site preparation, fire insurance, etc. As one of the speakers tersely stated, "for a contractor to omit any of these items would be fatal

and it would amount to just the difference between being able to accomplish a good job and break even, and getting in the hole and losing considerable money." (16 pp., *p.*)

### BRITISH ASSOCIATION, MANCHESTER MEETING, SECTION G.

TESTING TOOL STEELS, Professor A. B. Field.

The paper reports some data of an investigation of tool steels and cutting tools.

One of the first points to be determined was the degree of uniformity obtainable in the heat treatment of special tool steels, so that the results could be duplicated at will, and successive tools used for comparative operations could be depended upon to be uniformly similar. In this connection the dynamometer arrangement constructed by the late Doctor J. T. Nicholson, of the Manchester School of Technology, is of great interest. The forces exerted on the tip of the tool by the material being cut in ordinary heavy engineering work might easily exceed 10 tons, and it is necessary not only to measure forces of this order, but to do so without giving the tool sufficient freedom of motion to affect the cutting operation of the lathe. The first dynamometer made measured the most important component of the force, viz., that in the direction of the motion of the work relatively to the tool. The dynamometer which was used later measured the components of force in three directions at right angles to one another, and thus completely determined the resultant force on the tip of the tool, except that the exact point of application had necessarily to be estimated. That the tool could be given the necessary freedom for determining these three forces while it was making a cut in steel to a depth of 3/8 in. at a rate of feed of 1/8 in., with some six tons force on its tip, without impairing the normal operation of the cutting, may be considered a triumph.

More recently, a device has been constructed in the shops of the Manchester School of Technology for determining a corresponding system of forces which arises in the operation of a milling cutter. In this case, the forces exerted upon the work in both the tangential and radial directions were measured on a dynamometer, diagrammatic provision being made for a possible negative force and the axial force being measured on the milling spindle itself. In the laboratory of the same institution, a comparatively rapid method has been developed for determining the ultimate endurance to rapid reversals in the material by a short series of direct reversal tests upon each of half a dozen or so specimens of the material.

As the Proceedings of the British Association containing the above paper are not available, this abstract has been made from a report in *Page's Engineering Weekly*, vol. 27, no. 577, October 1, 1915.

### INSTITUTION OF MECHANICAL ENGINEERS

*Journal, no. 7, October 1915, London.*

The Theory of Grinding, with Reference to the Selection of Speeds in Plain and Internal Work (abstract)
Struts and Tie-Rods in Motion, H. Mawson (abstracted)

THE THEORY OF GRINDING, WITH REFERENCE TO THE SELECTION OF SPEEDS IN PLAIN AND INTERNAL WORK, James J. Guest.

The question of the best work surface-speed in grinding is one which is constantly being raised, and there is a universally accepted belief that it should have some definite value dependent not only on the abrasive, grit, and grade of the wheel, but on the material of the work. Opinions and practice vary widely as to what this value should be, and for many years the values used have steadily lessened.

In the paper, the author puts forward his theory of grinding, which is based rationally upon a consideration of the action taking place between the wheel and the work and of the power involved. The conclusion first reached is that the quantity which the author terms the normal material velocity must lie between certain limits. In cylindrical work the value of the normal material velocity is $\sqrt{2v^2t\frac{d \pm D}{dD}}$ where $d$ and $D$ are the diameters of the work and the wheel respectively, $v$ the work surface-velocity, and $t$ the depth of the cut; the positive sign is to be taken for external and the negative for internal grinding. If this quantity exceeds a certain value which depends on the grit and grade of the wheel and on the material of the work, the wheel will wear away too rapidly; while if it be less than a certain other quantity, the wheel will glaze.

The fact that a machine is designed to take up to a certain amount of power, limits the value of $vt$ for any particular grade of wheel; if $vt$ has any less value than this, the machine is not utilizing the full power supply. By considering these two controlling factors in combination, the methods of efficient grinding are deduced. The best work surface-speed thus depends not only upon the material of the wheel and of the work, but also upon their diameters and the particular machine in use, and the current belief that it should have a fixed invariable value is shown to be fallacious.

The case of a piece of work already on the machine and causing trouble in the grinding is first considered. If the wheel is wearing too rapidly, it is natural to reduce the cross-feed to check it, a course which is efficacious but of bad economy. It has been discovered by experience that it is better to reduce the word-speed until the wheel wears well enough. The author, however, shows that the correct course is to reduce the work-speed much further and to increase the cross-feed simultaneously.

When, on any particular machine, work of various diameters is handled, or wheels of different diameters are used, the best work surface-speed is shown to be proportional to $\frac{dD}{d \pm D}$. By taking numerical examples of plain (external) grinding, it is found that work of small diameter should run at a slower surface-speed than is suitable for work of larger diameter; considerations of vibration and chatter, however, frequently render it necessary to use less force upon slender work, and this leads to an increase of this natural surface speed. With work of large diameter, the formula leads to high surface-speeds combined with fine cross-feeds; the difficulty of using fine cross-feeds renders this undesirable, and it is proved that the way to overcome this trouble is to reduce the width of the wheel, which permits slower work surface-speeds and heavier cuts to be used.

The effect of wheel size and wear is then taken up; it is of little importance in plain (external) work, but lies at the root of the principal trouble in internal grinding, as it causes the

regime of the grinding to alter continuously. To secure the best output, the work-speed should be proportional to $\frac{dD}{d-D}$ in internal grinding, and the natural work-speed very high when the work is only a little less than the hole. The corresponding cross-feed will be small—so much so as to be unworkable, unless more power is used per inch of wheel-face than is the practice in external grinding. If the width of the wheel be selected so that the grinding can just take place, the wheel-face will be on the point of glazing. As it wears down in size, it at first works better, but afterwards commences to waste away. The work-speed should then be lowered and the depth of cut increased, which will alter the action so that the wheel again works well or tends to glaze according to the amount of the alteration.

The arc of contact, which is commonly supposed to be the important factor in internal grinding, has no direct effect. The area of contact, however, is shown to be a measure of the rate of removal of material, and in internal grinding a narrow wheel and a long arc of contact are necessary.

Change of wheel grade has a double effect. For a softer wheel, a smaller normal material velocity must be used, and at the asame time the value of $vt$ increased for any particular machine. This leads to lower work surface-speeds and heavier cross-feeds. Combined with the increase of power per unit width of wheel-face, adopted in modern machinery with the view of increasing output, the result during recent years has been the continuous lowering of the work-speeds used.

The theory has been treated somewhat discursively in the author's book on grinding machinery, but in this paper it is presented logically and stripped of all adventitious matter; only the needful properties of the wheel are involved so that the application may be as broad as possible.

### Struts and Tie-Rods in Motion, H. Mawson

The author shows how the stresses in a rod which is in motion and subjected to an endlong force, may be calculated; he shows further that the formulae which have been derived for forces in stationary struts are only special cases of those obtained for rods in motion.

He takes first the case of a uniform circular shaft of a certain weight per unit of length, rotating at a speed (in radians per second) in bearings which do not constrain it in any way and assumes that it is subjected to an endlong compressive force. He derives an equation which shows that as the speed increases, the critical endlong force rapidly diminishes and that if the speed be zero, then we have a stationary strut, loaded with a certain weight per unit of length and the critical endlong force is found to be Euler's load. The same equation gives an expression for the critical speed of the shaft, which is found to decrease as the endlong compressive force increases. Moreover, when this force is zero, the equation gives an expression for the whirling speed of a shaft rotating in bearings and not subjected to any endlong force.

The author considers next the case of a rotating shaft subjected to an endlong tensile force $F$ and derives an equation which gives an expression for the speed in radians and the endlong tensile force $F$, also showing that the greater the value of $F$, the greater the angular velocity has to be before whirling takes place; hence, the whirling might be prevented by applying an endlong tensile force to the rotating shaft.

Next the author takes the case of a uniform rod, every portion of which describes a vertical circle and is subjected to an endlong compressive force $S$. He discusses the three possible cases covering the relation between the position of the rod, weight and centrifugal force, and derives certain equations which, among other things, prove that a circular rod, rotating as a coupling rod and subjected to an endlong compressive force, will whirl at the same angular velocity as it would if rotating as a shaft and subjected to the same endlong force, no matter what the radius of the vertical circle may be, since the moment of inertia about all axes of bending is constant.

The same equation for the maximum stress has been applied to a particular locomotive coupling rod, which broke while in service, and the results are tabulated in Table 0. The particulars and dimensions relating to this rod (I-section) are as follows: Diameter of cylinder, 18 in.; working steam-pressure, 160 lb. per sq. in.; radius at which rod acts, 12 in.; distance between centers, 8 ft. 11 in.; diameter of wheels to which rod was attached, 6 ft. mean sectional area, 6.53 sq. in.; mean moment of inertia $I$, about the axes of bending, 12.5 in.$^4$ units; mean weight per inch run, 1.85 lb. Calculations have been made for steam pressures of 160 and 200 lb. per sq. in. at different speeds of the engine, the direct stress $\frac{F}{A}$ being taken as the full steam pressure on the piston divided by the sectional area of the coupling rod.

It will be noticed that the stress increases very rapidly as the speed of the engine increases, and that at the high speeds an increase in steam pressure does not appear to have as disastrous an effect as an increase in speed. It is also seen that at 60 miles per hour, with the ordinary working pressure of 160 lb. per sq. in., the stress in the rod is 9.82 tons per sq. in., which is rather high considering that the stresses are of an alternating character, first compressive and then tensile. Should the wheels slip upon the rail, it is quite possible that they may revolve at a speed equivalent to 80 or more miles per hour, and the stresses may then exceed the elastic limit. The rods have been known to break in cases of derailment owing to the high speed with which they rotate in such cases.

The author cites the formulae for stresses in uniformly loaded coupling rods given by Professor Perry and Professor Unwin, and shows that while the results obtained by applying the Perry formula agreed very closely with the determinations obtained from the author's equation, the results from the Unwin formula give stresses considerably below them.

Since the derivation of stresses from the equation given by the author is laborious, he suggests another method which gives results in very close agreement with those derived from the equation above referred to. Considering the coupling rod to be subjected to a uniform load of $w_1 = w + \frac{w}{g}a^2r$ lb. per unit run, where $w$ is the weight of unit length of the rod, the bending moment due to this $= \frac{w_1 l^2}{8}$

The stress due to this bending moment $= \frac{w_1 l^2}{8Z} = f_m$

The deflection at the center due to this uniform load is

$$\frac{5}{384}\,\frac{w_1 l^4}{EI} = \delta$$

The stress due to the pressure $F$ acting at a distance $\delta$ from the axis $= \frac{F\delta}{Z} = f_n$

The direct stress $= \frac{F}{A} = f$

Total stress $= f + f_m + f_n$

Treating the rod in this manner, the results of Table 4 have been obtained for different speeds of the engine with the steam pressure at 160 and 200 lb. per sq. in. (11 pp., 3 figs., *tm*).

TABLE 4 STRESSES IN A COUPLING-ROD AS A FUNCTION OF SPEED OF ENGINE AND STEAM PRESSURE

| Speed of Engine in miles per hour | Steam Pressure 160 lb. per sq. in. | Steam Pressure 200 lb. per sq. in. |
|---|---|---|
| | Stress in Rod Tons per sq. in. | Stress in Rod Tons per sq. in. |
| 10 | 3.2 | 3.95 |
| 20 | 3.78 | 4.60 |
| 30 | 4.70 | 5.25 |
| 40 | 6.18 | 6.8 |
| 50 | 7.70 | 8.7 |
| 60 | 9.82 | 10.8 |
| 70 | 12.30 | 13.3 |
| 80 | 15.2 | 16.4 |

## SCIENTIFIC SOCIETY OF THE ROYAL TECHNICAL COLLEGE, GLASGOW

Safety Valves, D. MacNicoll.

As the original publications of the Society are not available, the abstract is taken from the reprint of the paper in the *Mechanical World* (London, vol. 58, nos. 1497 and 1499, September 10 and 24, 1915). The date of reading of the paper is not given.

With the advent of oil fuel in the British Navy, determinations of the sizes of safety valves based on a formula using coal as a factor, proved altogether inadequate. (The formula for the sizes of safety valves in the Board of Trade rules is derived from the area of fire grate and steam pressure and with the Admiralty, from the heating surface and steam pressure.)

The first oil fuel vessel in which trouble was experienced was H. M. S. *Cossack,* a torpedo boat destroyer. During the accumulation trial, the steam pressure rose to a dangerous extent with the pointer of the gage going up rapidly; to prevent an accident, the easing gear was applied. It was observed that it required only a very small additional lift to the valves, somewhere about $^1/_{64}$ in., to keep the accumulation pressure below the danger point, and that the pressure in discharge steam was excessive. These valves were quadruple, 3.625 in. diameter, with a discharge pipe of 7.25 in. bore. New valves were then fitted, also quadruple, but 3.75 in. in diameter, with two discharge pipes, each of 7.25 in. bore. This was found satisfactory.

Meanwhile Mr. Gibson, of Cammell, Laird & Company, carried out a series of interesting experiments on one of the original valves. A small steam cylinder, fitted with a piston, was mounted on the boiler shell in the vicinity of the safety valve and the piston attached to the easing gear in such a manner that when the piston moved upwards, the valve was eased. The bottom of the cylinder was connected with the discharge steam space of the safety valve, and the effect was that excessive pressure in the discharge steam space assisted the valve to lift instead of preventing it from doing so. Fig. 4A shows this arrangement. The trials were most satisfactory.

About the same time, another torpedo boat destroyer, H. M. S. *Swift,* was equipped with quadruple 3.375 in.

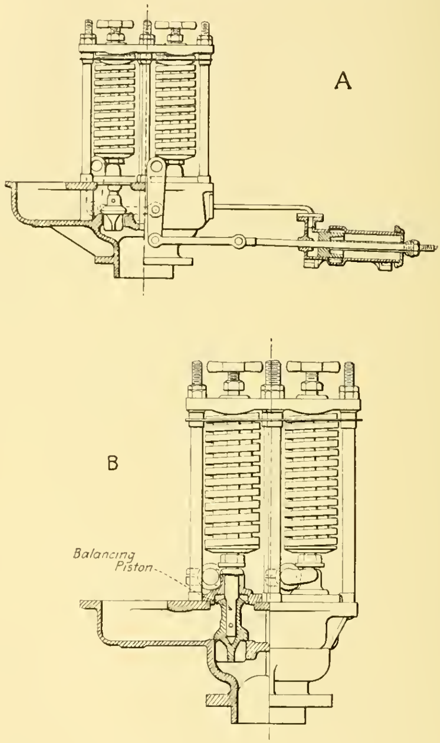



Fig. 4 Safety Valves for Oil Fired Boilers (Marine)

valves; but instead of having an external cylinder, each valve was fitted with a balancing piston or disc, which neutralized the effect of back pressure, (Fig. B). It proved entirely satisfactory, so far as the accumulation allowance was concerned, and it also proved that the size of the safety valve was sufficient, but that a much larger waste steam pipe would have to be used if no balancing arrangement was adopted. In consequence of the experience gained, the firm of Cockburns, of Cardonald, decided that in the future, for the Admiralty type of safety valve, they would determine the size of valves from the evaporation expected under accumulation conditions, and from that, the discharge pipe

area should be based on passing the evaporation at a pressure not exceeding 15 lb. pipe gage, or 30 lb. per sq. in. absolute. A large number of valves were constructed under these conditions with perfectly satisfactory results.

## SOCIETY OF ENGINEERS

*Vol. 6, nos. 8 and 9, August and September 1915, London*

THE UTILIZATION OF SOLAR ENERGY, A. S. E. Ackermann

Discussion of the problem of utilization of solar energy as a source of motive power. A brief history of former efforts is given, among other things, the Willsie experiments at Pasadena, California, at Hardyville, Arizona, and St. Louis, Missouri. Four appendixes are given. Appendix 1 refers to the Shuman-Boys absorber in Egypt; in Appendix 2 the author derives the following equation of the theoretical efficiency of a solar heat absorber:

$$\eta = \frac{Dsa - pk(T^4 - {}^2/_3\,A^4) - (1 - r)Dsa}{Dsa}$$

where $D$ is the width of the reflector in feet; $p$, the perimeter of the boiler in feet; $r$, the efficiency of silvered glass as a

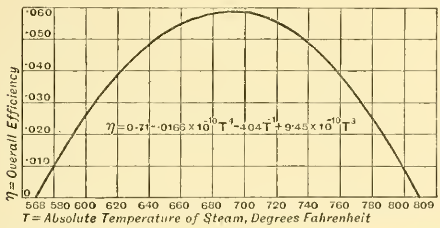



FIG. 5 CURVE SHOWING THE RELATION OF THE OVER-ALL EFFICIENCY OF THE 1913 SHUMAN-BOYS SUN-HEAT ABSORBER (WITH NAKED BOILER) COMBINED WITH A CARNOT ENGINE, TO THE ABSOLUTE TEMPERATURE OF THE BOILER STEAM

reflector of heat; $s$, the solar constant in B.t.u. per square foot per minute = 7.12; $a$, the coefficient of atmospheric transmission; $T$, absolute temperature of the boiler in deg. fahr.; $A$, absolute temperature of the reflectors in deg. fahr. The temperature $A$ was found to be about 9 deg. fahr. above the shade temperature of atmosphere. The efficiencies thus calculated were compared with those obtained by experiment, and were shown to be rather higher.

In Appendix 3, the author demonstrated that the best commercial result on over-all efficiency obtained from a solar heat absorber and engine did not necessarily correspond with the maximum thermal efficiency of the absorber alone. The equation for the over-all efficiency of the plant is

$$\eta_o = \frac{[Dsa - pk(T^4 - {}^2/_3\,A^4) - (1 - r)Dsa]\ (T - 568)}{Dsa\ T}$$

where $T$ is the absolute temperature of the steam and 568 the absolute temperature of the condenser in deg. fahr. (taken as constant), the other symbols having the same meanings as in the equation given in Appendix 2. Assuming the mirrors to have a temperature of 100 deg. fahr. and inserting the values of the other quantities (except $T$), the equation becomes:

$$\eta_o = 0.71 - 404\,T^{-1} + 9.45 \times 10^{-10} T^3 - 1.664 \times 10^{-12} T^4$$

Differentiating this equation with regard to $T$, and equating the result to zero, the value of $T$ is obtained, which gives the maximum over-all efficiency under the given conditions.

This being done, it is found that $T$ = (231 — 461) deg. fahr., corresponding to a steam pressure of 21 lb. sq. in. abs. Inserting this value of $T$ in the equation just given, the *theoretical* maximum over-all efficiency of the Meadi absorber, combined with a Carnot engine, is found to be 5.9 per cent., while the *actual* maximum was 4.32 per cent. The relative efficiency was thus 73.2 per cent. This means that nearly three-quarters of the boiler horse power theoretically possible under the stated conditions was obtained.

Instead of differentiating the equation to $n$, it is possible to insert various values of $T$, and thus calculate the corresponding values of $\eta_o$ and plot the results. The value of $T$ which gives the maximum commercial economy is then readily seen in the inspection to be 231 deg. fahr. as before, (Fig. 5). It is also seen that $\eta_o = 0$ when $T$ = 568 deg. fahr. (= $T_2$, the temperature of the condenser), or when $T$ = 809 deg. fahr. The latter corresponds with a steam pressure of 131 lb. sq. in. abs., and means that the loss by radiation and conduction from the boilers and by the inefficiency of the mirrors would then be equal to the solar heat received.

Appendix 4 is a bibliography of the subject.

## CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles in the Survey.

## MEETINGS

### MILWAUKEE, SEPTEMBER 1915

About 150 members and guests attended the opening meeting of the Milwaukee Section in September. Col. Henry A. Allen, Mem. Am. Soc. M. E. and consulting engineer for the City of Chicago, gave a very interesting, illustrated talk on Municipal Waste, describing very fully the development and present status of the garbage and ash handling in Chicago. He also gave a short talk on the Eastland disaster and dwelt quite fully on the stability of vessels. Col. Allen closed his talk with a description of the new Winslow high pressure steam boiler.

### PROVIDENCE, SEPTEMBER 22

The opening meeting of the Providence Association of Mechanical Engineers was held in Engineering Building, Brown University, on Wednesday evening, September 22, at which F. H. Small presented a paper on the Manufacture of Leather Belting. Mr. Small has had a wide experience in this line and presented to the meeting an unusually interesting account of the various processes involved from the curing of the leather hides down to the selection of the proper size of a belt for any particular condition of driving. During the latter part of his address, he devoted considerable attention to many of the important but too little understood features of the proper application of leather belting in power transmission; he showed that, where oftentimes a belt drive has proved unsatisfactory, a very slight change in the width or thickness of a belt will correct the fault and give the belt a very greatly increased life.

### CINCINNATI, SEPTEMBER 30

A joint meeting of the Cincinnati Section of The American Society of Mechanical Engineers and the Engineers' Club of Cincinnati was held on the evening of September 30. John S. Crandell, formerly of the Highway Engineering Department of the Pennsylvania State College, spoke on Coal Tar Products and Road Building. The speaker began by carefully defining such terms as tar, bitumen, and asphalt. He discussed at some length the tar derivatives and the characteristics of coal-gas tar, water-gas tar, coke-oven tar and the characteristics of the various oils and pitches obtained from different coals, and from the same coals by varying the process. Retorts for distillation were illustrated by lantern slides. Some of the fundamental principles of road building were discussed by the speaker and the use of tar products in the top dressings of roads was elaborated in some detail. Various methods of forming the surfaces and distributing the pitch were illustrated by moving pictures. The paper was one of great interest and provoked considerable discussion.

The president of the Engineers' Club, who represented the club at a recent meeting of the Dixie Highway Commissioners at Chattanooga, gave a brief report of that meeting and showed on a map the various routes that had been decided upon, including the one through Cincinnati. About 75 members and guests were present.

### NEW YORK, OCTOBER 12

The opening meeting of the New York local section was held on October 12, when a paper by Frank B. Gilbreth, Mem. Am. Soc. M. E., on Motion Study for Crippled Soldiers was presented by Robert T. Kent, Mem. Am. Soc. M. E. Edward Van Winkle, chairman of the section, presided at the meeting.

In carrying out his development of scientific management in industrial plants and hospitals, Mr. Gilbreth has recently spent several months in Germany, and while there he became much impressed with the great problem which will confront the world of training the millions of soldiers crippled by the war to resume their places in industrial life and become self-supporting. He has been asked to put the results of modern management in general, and motion study in particular, at the disposal of those in active charge of training the cripples.

The first step in adequate placement of men through motion study lies in visualizing the motions used, or necessary, in any given type of work. This is done by means of the simultaneous cycle motion charts, devised and used by Mr. Gilbreth, which record the inter-relation of the individual motions and cycles of motions used in any method of performing any piece of work. By analysis, he is able to work out from the charts new methods of doing a piece of work. Thus many types of work formerly considered possible only for the man in complete possession of all his members and faculties can be adapted to the maimed or crippled worker.

The data included in these charts are gathered through various methods of making motion studies. From these records are made motion models that make it possible for teacher and learner to visualize the desired motions.

By means of these methods, the selected elements of skill and experience can be transferred in a new syntheticized cycle of least waste, to crippled learners where it is often necessary to specialize on some particular sense training.

While this method of study is bringing in gratifying results, no great headway can be made with the crippled soldiers' problem without worldwide coöperation. Such coöperation has been forthcoming wherever interest has been aroused, but Mr. Gilbreth begs for more. He needs photographs, records, and histories of cases where cripples have been taught successfully to do work and he also needs suggestions for adaptations of machines, tools, and other equipment or surroundings to workers.

### MILWAUKEE, OCTOBER 13

At a meeting of the Engineers Society of Milwaukee on October 13, H. J. Manger delivered a very interesting talk on the Electric Heating Industry. The local electric light company sent over a rather complete line of heating and cooking apparatus, and several of the company's demonstrators were present who baked some cookies and broiled some steak. Mr. Manger said that the local company has just adopted a rate of 2 cents per kw-hr. for cooking. He said that this would cost the average family from $2.00 to $3.00 per month for electric cooking.

### BUFFALO, OCTOBER 13

On October 13, a joint meeting under the auspices of the American Institute of Electrical Engineers was held in Boston, following out a new scheme of coöperation among the Civil Engineers, the Electrical Engineers and the Mechanical Engineers. The subject was Load Dispatching as Handled by Large Electrical Power Distributors. Mr. P. Kent of the Boston Edison Company and Mr. Masters of the Boston Elevated Company presented papers and lantern slides. J. M. Cushing of the Electrical Engineers explained

the scheme of coöperation among the engineering societies. The guest of the evening was J. J. Carty, president of the American Institute of Electrical Engineers, who spoke on the value of engineering societies to its members.

### BUFFALO, OCTOBER 20

On Wednesday evening, October 20, the Engineering Society of Buffalo held its first meeting at the Hotel Statler. A dinner was served at which about 150 members participated. After the dinner, W. B. Hunter, director of the Fitchburg (Mass.) High School, gave an address on The Training of Mechanics, laying special emphasis on the work that has been done with the Fitchburg coöperative system. This system consists in having relays of students, one relay in the High School, while the second relay is working in the shops. The succeeding week the two sets of students change places. This system is working out very successfully and there is no question that it is a step forward towards the solution of the problem of getting mechanics.

There was a discussion following the address. Over 200 members were present at this meeting.

### MINNESOTA, OCTOBER 21

The regular meeting of the Minnesota Section was held at the University of Minnesota on October 21 at which Quincy A. Hall, Mem. Am. Soc. M. E., presented a paper on the History of the Panama Canal. This paper covered the time from the first activities of the French down to the present time. Mr. Hall was well qualified to handle the subject as he has spent six years in the Canal Zone as a testing engineer.

## NECROLOGY

### JOHN PARKER

John Parker was born in Mansfield, England, on March 28, 1864, and came to this country in 1887. For four years, he was employed in the drafting department of the Corliss Steam Engine Company in Providence, R. I., and in 1891, he accepted a position with the Brown and Sharpe Manufacturing Company. In 1893, he took active charge of their miller designing and in connection with this position also held that of assistant chief draftsman, 1895-1902. As assistant chief draftsman he developed executive ability in putting work through correctly and efficiently, and many patents were granted to him chiefly in connection with his work on millers. He was in charge of the miller designing for this company up to the time of his death, which occurred on July 23, 1915. He became a member of the Society in 1909.

### JAMES P. TOLMAN

James P. Tolman was born in Boston, Mass., on November 7, 1847. He received his early education in the public schools of Boston and entered the Massachusetts Institute of Technology, from which he took the degree of Mining Engineer in 1868, which was the first class to be graduated from the Institute. In 1870, he became superintendent of the Silver Lake Cordage Company of Newtonville, Mass. He then organized the J. P. Tolman & Company in 1884 which manufactured braided cord. In 1888, the Samson Cordage Company in Shirley, Mass., was organized as successors of the J. P. Tolman Company and Mr. Tolman became president of the company, which position he held up to the time of his death. This company is one of the largest in the world manufacturing braided cord. Mr. Tolman became a member of the Society in 1894. He died at his home in West Newton, Mass., on July 28, 1915.

### ARTHUR S. MANN

Arthur S. Mann was born in West Medway, Mass., on September 4, 1867. He received his early education in the schools of Medway and graduated from the Massachusetts Institute of Technology with the degree of S.B. in 1888. The first two years out of college were spent with the George F. Blake Manufacturing Company. Following this he was with the West End St. Railway Company in Boston, Mass. From 1892-1894, he was with the E. P. Allis Company of Milwaukee as mechanical engineer. In 1894, he started a machine shop with F. E. Lammert in Chicago, building special machinery and conducting a general engine repair trade. He was vice-president of this company up to the time of his death, although he had taken no active part in the business since 1897.

In 1897, he became engineer of construction of the Ninety-sixth Street power plant and operating chief engineer of the various plants for the Metropolitan Street Railway Company of New York City. In 1901, he accepted a position with the Sydney St. Railway Company in Australia as construction engineer of power plants. In 1903, he went with the General Electric Company in Schenectady, N. Y., where he was engineer in charge of construction of their power plants and of the steam, air and water distribution of their entire works. Also he was at the head of the installation of the new powdered coal system and had charge of the design of their new furnaces and boilers.

Mr. Mann became a member of the Society in 1900. He died on June 3, 1915.

## PERSONALS

William I. Ballentine has resigned his position as general superintendent of the Link Belt Company's Indianapolis plants.

J. Ralph Bolgiano has severed his connection with the Taylor-Wharton Iron and Steel Company of High Bridge, N. J., and is now associated as an engineer with The Emerson Company of New York, efficiency engineers. He has been assigned to work in the Chillicothe, Ohio, works of the B. & O. S. W. R. R.

Frank L. Dalas has accepted a position with the Youngstown Sheet and Tube Company of Youngstown, Ohio, in the electrical and mechanical department for the new extension of the plant.

Frank H. Schubart, until recently connected with the engineering department of Wheeler Condenser and Engineering Company, Carteret, N. J., has been appointed district manager of the St. Louis territory of the Company.

Alfred E. Ballin has become associated with the McIntosh and Seymour Corporation, Auburn, N. Y., as general manager. He was formerly manager of the gas and oil engine department of the Snow Steam Pump Works, Buffalo, N. Y.

Thomas W. Harris, Jr., recently connected with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., as assistant to the works steam engineer, has accepted a position with E. I. du Pont de Nemours and Company, Wilmington, Del., as assistant in the purchasing department.

Jean M. Allen has become associated with the Floesch Con-

struction Company, Inc., Cape Girardeau, Mo., as manager and engineer.

Percy C. Smith has resigned his position as sales manager and mechanical engineer for the Roto Company, Hartford, Conn., to accept the position of factory manager for the Maxim Silencer Company, Hartford, Conn.

## STUDENT BRANCHES

### CARNEGIE INSTITUTE OF TECHNOLOGY

The annual banquet and final meeting of the Carnegie Institute of Technology Student Branch was held on June 4, 1915. The following officers were elected: Benjamin Schwartz, president; L. W. Sherwood, vice-president; J. T. Eaton, secretary, and J. M. Guter, treasurer.

The business meeting was followed by a paper on Heat Transmission into Steam Boilers, by Henry Kreisinger of the United States Bureau of Mines. Mr. Kreisinger has been engaged in experimental work of this nature in the government laboratories for several years and is the author of a well known text book on the subject of boiler practice. Mr. Kreisinger opened his address by differentiating between the ordinary conception of a steam boiler as including the furnace, stack, etc., and the boiler as a steam generating unit, in which reference he treated it. He defined the problem of heat transmission as that of getting the heat from the gaseous products of combustion and the residue in the fuel bed, and into the boiler.

Mr. Kreisinger traced the path of the heat from the firebox through the intervening space, a layer of soot, the boiler plate itself, a layer of mud and scale and a layer of steam to the water itself. He went into detail concerning radiation, absorption, conduction and convection in this connection. His investigations have shown that the path of the heat from the fire to the boiler surface is the slowest. A chart made from the direct results of an experiment showed how the temperature drop in this part of the heat path is enormous in comparison with the other parts. The results also showed a drop of 2150 deg. fahr. from the fire to the boiler surface, a drop of 40 deg. through the metal tube, and a drop of 15 deg. through the layer of mud, scale and steam on the inside.

The next consideration was given to the possibility of increasing the rate of heat transmission into boilers and thereby increasing the capacity of given units. Three possibilities presented themselves: Increased initial temperature, increased density of the furnace gases and increased velocity of the furnace gases. The idea of increasing the density was given up because it opposed high initial temperature. Limits were assigned to the initial temperature and gas velocity because these conditions when extremely high are accompanied by great losses in the efficiency of the fuel.

A considerable part of the paper was given up to a description of the apparatus used in performing the experiments that led to these conclusions. The temperatures were measured by means of platinum, platinum-rhodium thermocouples. Those used inside the boiler were imbedded in the tube, and the one used for taking temperatures at different points in the flue was mounted on an eccentric at the end of the long rod. Every precaution was taken to avoid error and the known inaccuracies were taken into account in calculating the results.

Mr. Kreisinger defined true boiler efficiency as the ratio of the heat absorbed by the boiler divided by the heat available for absorption. The heat available for absorption being the part of the heat in the hot gases which is above the temperature of steam. He then showed how more rapid transmission into the boiler will increase the amount of heat that is absorbed and thereby increase the efficiency of the boiler.

### KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College on October 12, the following papers were presented: The Value of Public Speaking to the Engineer, by Professor Emerson of the Public Speaking Department of the College; A Brief History of the A.S.M.E., by Dean A. A. Potter, Dean of the Engineering Division of the College, and The International Harvester Company's Gas Engine and Cream Separator Factory at Milwaukee, by Prof. W. W. Carlson, Professor of Shop Practice of the College. Professor Carlson described the route that the pig iron takes in the factory to the finished product and told of the many time saving devices which that company uses.

### PENNYSLVANNIA STATE COLLEGE

The first meeting of the year of the Pennsylvania State College Student Branch was held on September 30, at which Professors Moyer and Mease gave talks on the object of the A.S.M.E. and benefits which could be derived from it. They together with Professors Diemer, Wood and Bates urged the students to keep in touch with the Society by subscribing to The Journal and requested that as many of the senior students as possible try for the Junior Prize which has been offered by the Society. Dean R. L. Sackett, the newly appointed head of the Engineering School, told of his desire to further the interest in the Student Branch and said that he would do all that he could to coöperate with it.

### POLYTECHNIC INSTITUTE OF BROOKLYN

At the first meeting of the Student Branch of the Polytechnic Institute of Brooklyn, 30 new men were admitted to membership in the branch and Dr. M. C. Ihlseng, consulting professor of the Institute, was made an honorary member.

H. A. Brandt, chairman of the Branch, presented a paper on the Manufacture of Shrapnel. He described the intricacies of their manufacture and carefully explained the complex and difficult processes. Prof. W. D. Ennis of the Mechanical Engineering Department related his summer experiences with dynamite which he used on his farm for clearing away rocks and shattering hard clay to permit better drainage and for digging a ditch.

### PURDUE UNIVERSITY

The opening meeting of the Purdue University Student Branch was held on October 2. The meeting was attended by 126 students and faculty and 38 applications for membership were received. Dean Benjamin, Prof. G. A. Young, honorary member of the branch, Prof. L. V. Ludy of the Engineering Laboratories and Prof. L. W. Wallace addressed the students on the advantages to engineering students of becoming affiliated with a student section of the Society, and urged them to join. They also spoke of the many opportunities and importance of belonging to an engineering society and the relation of the student section to the Society.

At a meeting of the branch on October 16, W. F. Borgerd addressed the meeting on Electric Starting and Lighting Devices for Automobiles. He explained the different systems in use on several of the most important cars. He laid stress on the generators used on starting devices and their faults from a repair-man's point of view, and said that the principal fault with them was the difficulty in getting the connection between the engine and the dynamo. Mr. Borgerd also spoke on the care of storage batteries especially during the winter.

### RENSSELAER POLYTECHNIC INSTITUTE

The first regular meeting of the Rensselaer Polytechnic Institute Student Branch was held on September 30, at which the following officers were elected: J. B. Lincoln, president; K. Keefer, vice-president; J. W. Hartman, secretary, and R. D. Culver, secretary.

Following the business meeting, Howard E. Stevens spoke on Diesel Engines. Mr. Stevens confined his remarks to the two types of engines manufactured by the McIntosh and Seymour Corporation of Auburn, N. Y.

### UNIVERSITY OF COLORADO

At the first regular meeting of the University of Colorado Student Branch on September 30, Prof. John A. Hunter,

Mem. Am. Soc. M.E., gave a review of the Spring Meeting of the Society at Buffalo. He also gave personal impressions of the various sessions and inspection tours and expressed his opinion of the value to be received from attendance at such a meeting. Later, other members of the Mechanical Engineering Faculty gave talks on interesting engineering undertakings and material encountered during the summer months, and mentioned opportunities for vacation work and experience open to students.

### UNIVERSITY OF NEBRASKA

A meeting of the University of Nebraska Student Branch was held on October 7. The following committees were chosen: On new members, H. C. Edwards, R. B. Saxon, L. L. Sharp and I. F. Smith; on Posters to Advertise the A.S.M.E., J. W. Galloway and D. E. Stokke; on A.S.M.E. Smoker, J. C. Baker, W. C. Chapin and C. S. Spaulding; on student programs for A.S.M.E., H. F. Holtz and R. B. Gillespie.

Professor Hoffman, head of the Department of Mechanical Engineering, spoke on the success of the engineer and told of the value of technical papers in keeping posted in modern engineering ideas. He advised that each man join some national society of engineers after getting out of school as well as taking an active part in student branches while in school. He also emphasized the value of The Journal.

### WASHINGTON UNIVERSITY

The student branch of Washington University held its first meeting of the year on October 12. The newly elected officers, consisting of Prof. E. L. Ohle, honorary chairman, John J. Summersby, chairman, W. H. Kurtz, vice-chairman, Edmond Siroky, secretary, and H. C. Keysor, treasurer, took up their respective duties. It was decided that student members be required to give papers before the branch; and if necessary the subjects are to be assigned by the executive committee.

Charles Proetz, a student, gave a talk on Carburetors and Mixing Valves in which he treated the history and present day practice in the design of carburetors. Although dwelling chiefly on American practice, he showed how it differed from that in Europe. The talk was made very interesting by specimens which he dissembled to show their parts. The talk was followed by discussions by Professor Ohle and Messrs. Brady, Meinholz and Siegerest.

### WORCESTER POLYTECHNIC INSTITUTE

The first meeting of the college year of the Worcester Polytechnic Institute occurred on October 1. Prof. Charles M. Allen spoke on Experiments with Gasoline. He illustrated his remarks by many simple experiments, some of which were very dramatic and which impressed the audience as being quite dangerous. By a combination of experiments, he illustrated in an easily understood way just those things which are likely to occur when gasoline, kerosene and alcohol are handled ignorantly. He also called attention to some of the serious cases resulting from its ignorant use as reported in the daily press, explaining the sequences which must have taken place to give the resulting explosions. One of the most interesting experiments was "the four-cycle engine." A covered tin pail was used for a cylinder. A hole near the bottom of the can held an ordinary spark plug and a hole in the cover was closed by a small tin box which served as a piston. An atomizer made an excellent carburetor, the mixture being introduced into the cylinder through a hole near the bottom. Mixtures of varying richness were sent into the cylinder and the effect was noticed when the spark was produced and the little tin box ascended. The lecture was concluded with a "fire eating" experiment in which the lecturer lighted his breath after inhaling a quantity of gasoline vapor through a cigar. It should be added that Professor Allen "washed his hands" of all responsibility for the safety of anyone who might try to repeat his experiments.

## EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

### POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.*

286 Experienced designer familiar with machines, tools and jigs or forgings and pressed metal work. Location New York State. Apply by letter.

287 Manufacturing concern in the East wants capable designers and draftsmen with experience in the mechanical design of steam turbines. Special inducement for a leading designer and for squad leaders; also for a man with designing experience on condensers. Apply by letter, stating age, education, experience, salary desired, etc.

290 Mechanical draftsman experienced in the charge of a drafting room, and thoroughly familiar from practical experience with designing, erecting and handling machinery for elevating and conveying material in factories, warehouses, mills, mines, quarries, sand and gravel plants; also gravel washing and screening machinery; a complete knowledge of mechanical power transmitting machinery, and its installation. Correspondence will be kept strictly confidential. Give experience, addressing Lock Box 3097, San Francisco, Cal.

306 Large shop in Nashville, Tenn., desires engineer who is particularly well trained in electrical matters; work for present, mainly survey of shops to determine what future equipment is needed both in the shops and power plant. Salary $1200 to start.

307 Competent engineer to prepare estimates and cost sheets for manufacture of war munitions. Location New York.

308 Draftsman experienced in design, layout and construction of refrigerating and ice-making plants. Apply by letter, stating experience, salary expected, etc. Location Connecticut.

309 Appraisal engineers for series of plants devoted to various branches of industrial chemistry. It is desired to secure a force of engineers competent to take off quantities from the various plans, to verify the execution and to measure up the work in the buildings; fitness of the plant for its chemical purposes is not in question. Employment will last from two to three months; possibly subsequent employment for some members of the force on a more permanent basis.

314 Draftsman for wood factory building. Must be familiar with piping and belt drives. Apply by letter.

316 Superintendent or foreman competent to take charge of plant and experienced in every department required in the manufacture of rifles. Apply by letter.

318 High grade designer of machine tools; preference for a man who has had from 15 to 20 years' experience and one who is a practical shop man as well as a capable designer. Location Rochester, N. Y.

319 Sales engineer on steam turbines, centrifugal pumps, steam engines, hoisting machinery, feed water heaters, steam separators, etc. Apply by letter; location Pittsburgh.

321 Qualified engineer to conduct organization work for Canadian concern making all classes of fencing materials; one prepared to consider short term engagement. Apply by letter.

322 Assistant factory superintendent, one experienced in pump work. Location New York.

324 Three or four competent men to act as foremen in manufacturing plant, in assembling of mechanical parts ot munitions. Salary $100 to $125 a month. Location New Jersey.

325 Paper mill engineer; must have initiative and be competent to take charge of all work in the mechanical engineering of a large paper mill. Applications should be accompanied by a statement of age, qualifications, and salary expected. Location Eastern Massachusetts.

329 Several expert mechanical draftsmen in ordnance work department. Location Maryland.

331 Designer, thoroughly familiar with design of firearms, especially gun stocks. Location New York.

334 Wanted time study man, preferably one having technical school training, subsequent machine shop experience, time study and efficiency work. It is essential that time study man be an experienced machine tool operator who can demonstrate any standards set by operating the machine tool. State fully training and experience, present position and minimum salary to start with this company. Location Buffalo, N. Y.

335 Partner wanted. Electrical engineer with experience and clientele will join mechanical engineer who is likewise equipped. Middle West preferred. Capital furnished and required. P. O. Box 617, Chicago.

339 Technical graduate or practical man with experience in design of gas and oil fired furnaces; structural iron work, especially foundations for machines subjected to heat; and structural steel containers for bulky material, as coal hoppers, etc. Apply by letter. Location New York.

345 Massachusetts manufacturer of small electrical apparatus, in quantities, requires the services of an assistant purchasing engineer for the inspection of incoming materials; applicant must be thoroughly familiar with electrical, insulating and composition casting materials, with practical knowledge of metal working and similar machinery; state details under headings of age, nationality, education, practical experience, salary, when at liberty.

346 Young engineer on development and sales of alloy steels as used in manufacture of automobiles and kindred purposes. Location Pennsylvania.

## MEN AVAILABLE

*The published notices of "men available" are made up from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.*

K-304 Member, M.E. and E.E., age 35, with nineteen years' practical experience in bolt and nut manufacture, rolling mills and tube mills, and light and heavy forging. A-1 on design and plant development. At present superintendent of agricultural forge works. Location lake or coast city. Salary $4000.

K-305 Young mechanical engineer with three years' experience desires position as assistant to refinery manager or superintendent of large petroleum company in vicinity of New York.

K-306 Member, technical graduate, age 36, experienced in design and construction of structural steel work, machine tools, shop layout and arrangement of machinery, efficiency management, accounting and costs, works management, planning and routing, orders and stores, and also with experience as sales engineer, desires to become associated with a shipbuilding concern or an allied industry. Prefers to locate in New York or Philadelphia.

K-307 Member, M.E., twenty years' varied practice in general engineering and capable of assuming responsibility and control, an experienced designer, and one who has traveled extensively, desires to get in touch with concern requiring a reliable man in executive shop or office position. Salary $3000.

K-308 Technical graduate, age 24, three years' experience, two in manufacture and design of hydraulic machinery, one in plant department of New York public service corporation, desires a position in the engineering department of manufacturing or operating company located in Middle West.

K-309 Technical graduate, wide experience as railway mechanical engineer, machinist, motive power draftsman and mechanical engineer, desires position along these lines, or one as mechanical inspector, assistant superintendent of motive power, or assistant to general manager. Location immaterial.

K-310 College man, both electrical and mechanical, with fourteen years' experience in engineer's office, textile and rubber factories and electric light company, desires position in engineering or mechanical department of some large industrial concern, with consulting engineer or electric lighting company.

K-311 Associate-member, age 34, with seven years' experience as designer, chief draftsman and assistant engineer in the automobile and gas engine line, and two years as designer of gasoline mine tractors and mining machinery in general, wishes position as chief draftsman or assistant engineer in concern manufacturing along these lines. Location preferred New York.

K-312 Member, graduate engineer, age 40, American, twenty years' experience as salesman and office manager for company making air moving machinery and power apparatus, well acquainted with manufacturing plants, engineers and architects in New York territory, wants sales representation for mechanical apparatus on salary, or salary and commission basis. Location New York.

K-313 Junior member, M.E., age 26, three and one half years' experience in railroad motive power and mechanical department work, desires position with railroad or locomotive manufacturer with chance for advancement. At present employed.

K-314 Member, technical graduate, with twelve years' experience and who has made tests on boilers, engines, stokers, etc., and who has advised on fuel and made plans and specifications for new work, desires position with private firm or consulting engineer to superintendent of production of power.

K-315 Mechanical engineer with several years' experience in pump business as designer and chief draftsman is open for position.

K-316 Graduate mechanical engineer, age 31, thoroughly experienced in modern publicity work as applied to products of a mechanical nature, is open for position as advertising manager. Replies are solicited only from high grade firms that believe in clean cut, dignified methods, and are willing to pay a suitable salary for capable service.

K-317 Sales engineer, district office manager or agent, technical graduate M.E., ten years' successful sales record handling power plant equipment and problems in power transmission, covering a wide field of industries, seeks similar position with greater opportunities. At present employed.

K-318 Member, who has had charge of some of the leading foundries of the country and is capable of handling any foundry proposition, desires position as ganeral manager or superintendent of foundry.

K-319 Junior member, Columbia graduate M.E., 1913, two years' experience in production and drafting department, desires position in New York with chance for advancement. At present employed.

K-320 Mechanical, electrical and structural engineer desires position of responsibility with electric power company, engineering concern or railroad company with chance of advancement. At present employed as assistant engineer of construction on two 15,000 kw. stations.

K-321 Member, mechanical and electrical engineer, age 37, married, technical graduate, fifteen years' experience chiefly in design, construction, and operation of power plants, street railways and heavy machinery, would prefer position as master mechanic, superintendent or chief engineer.

K-322 Member, seventeen years' experience, with ability to determine the most economical method of manufacture, and to supervise the design and building of tools, punches, and dies, milling fixtures, jigs and screw machine tools, or other equipment such as special machinery, and one who can determine cutting speeds and feeds and piece work rates, also the installation, care and maintenance of the power plant and transmission, desires position as master mechanic where experience would be of value.

K-323 Member, age 35, with an unusually thorough experience in rubber mill engineering, including developments, reports, designs, specifications and contracts for buildings, power requirements and manufacturing equipment, desires position with consulting engineer or large rubber mill. Salary $4000. At present employed.

K-324 Junior member, age 31, married, technical graduate in mechanical engineering, five years' experience in power plants, testing investigations, and general mill engineering, wishes position with progressive company as assistant works manager, mechanical engineer, or similar capacity. Would prefer to become associated with the automobile industry.

K-325 Member, with successful and satisfactory record and wide acquaintance among automobile and automobile parts manufacturers, now holding position as sales and advertising manager, desires similar position with company.

K-326 Member, fifteen years' experience as designing and executive engineer, has specialized in machine design, power economy and mill supervision, desires position. Specially qualified for paper mill work.

K-327 Member, technical graduate, age 30, ten years' experience in treating, testing and micro-structure of steel; practical knowledge of the treatment of steels to obtain best physical and machining properties; capable of eliminating all troubles in the working of steel and manufacture of steel products.

K-328 Member of the Society, technical education and shop experience, age 38, married, sixteen years' experience with two railroads and one locomotive manufacturer, designing and constructing locomotives, cars, automobiles, motor cars and special railway equipment, desires position with a railroad company.

K-329 Industrial engineer, analytical and creative ability of the highest order; excellent manager of help, experienced in textile, food and manufacturing plants, mine quarries and department stores.

K-330 Technical graduate, age 31, nine years' broad experience in designing, manufacturing and testing special machinery, also delicate instrument work, thoroughly familiar with drawing office methods, pattern, foundry and machine shop practice, good executive, can handle correspondence, and draw up specifications, desires a position. Location immaterial.

K-331 Member of the Society, eight years' practical experience in general mechanical engineering, and four years in the installation of scientific management, desires a position with a progressive concern as efficiency or production engineer.

K-332 Ordnance engineer, member, M.E. degree 1913, age 35, married, fourteen years' experience, five and one-half years in army ordnance department, three and one-half years captain of coast artillery, completed ordnance school of application, familiar with electrical machinery and gas engines, commended for management and also familiar with efficiency systems, desires administrative position in development of military manufacture.

K-333 Member, age 33, Cornell graduate, twelve years' experience in machinery manufacture, design, sales, installation and operation, at present sales manager in Chicago for large machinery corporation, would consider proposition to fill responsible executive position. Location immaterial.

K-334 Junior member, technical graduate, twelve years' experience as chief engineer, designing, estimating, constructing and selling steam engines and boilers, steel, plate work, elevated tanks and towers, and general foundry and machine work, successful sales record, desires position. Immediate salary secondary to good opportunity for advancement.

K-335 Professor of mechanical engineering in a Canadian University, technical graduate of A-1 U. S. institution, both M.E. and E.E. training, has held responsible position in large manufacturing plant as well as important U. S. government post as engineering expert, also has had four and one-half years' successful teaching experience, and is author of engineering text books and numerous technical articles, desires teaching position in U. S. college.

K-336 Mechanical engineer, age 28, six years' experience, four years including foundry, machine shop, drafting and testing; two years power and mill machinery, installation and maintenance, wishes position.

K-337 Member, age 37, wide experience in factory engineering and power plant design, construction and operation, desires position as mechanical engineer or master mechanic.

K-338 Junior member, M.E., age 28, five years' experience in construction and equipping of manufacturing, supply or importing or exporting house. Familiar with far Eastern market.

K-339 Mechanical engineer, American, Junior, capable of taking charge of test floor, erection work, power plant investigation, technical correspondence, factory maintenance and purchasing. Energetic and reliable; can speak German. At present employed.

K-340 Mechanical engineer, member, age 40, married, twenty-five years' experience in the design of engines and water tube boilers, together with the plant and equipment for their manufacture, along the latest and most efficient lines, experienced also in the production of forgings, both drop and press work, desires administrative position in the development of the manufacture of all classes of forgings.

K-341 Member, technical education, twenty years' experience as general manager and treasurer of engineering works, also in charge of sales department, thorough practical experience and application of labor saving machinery in foundries and machine shops in various lines of general engineering work.

K-342 Young man, age 24, graduate of Lehigh University, has had two years' shop experience, desires position in engineering department of a manufacturing concern. Location immaterial.

K-343 Graduate of Worcester Polytechnic Institute, has had some experience in cost and efficiency work, interested in factory management and cost finding, would like position with manufacturing concern.

K-344 Member, age 32, technical graduate, solicits representation of a reputable firm, in Philadelphia, or would accept responsible position in a mechanical engineering capacity.

K-345 Associate-member, age 35, M.E., 1907, ten years' experience, five years in designing ordnance equipment and

machinery at the United Staes Naval Gun Factory, Washington, D. C.; five years with war department on the design of heavy machinery, familiar with mechanical and electrical transmission of power. At present in charge of drafting force, but desires administrative position in the development of machinery and manufacture of ammunitions of war.

K-346 Member, Executive and Mechanical engineer, graduate Massachusetts Institute of Technology, wide experience in railway operations, manufacturing and purchasing, desires position. Member Am. Ry. M. M. A., S. A. E.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Asphalt. Its history, manufacture and uses. Charles Ekstrand. Read before the Brooklyn Engineers' Club, May 13, 1915. Gift of author.

Atlantic Intra-Coastal Waterway. Official Survey Lines and present status of the work in its various sections. *Philadelphia, 1915.* Gift of Atlantic Deeper Waterways Association.

Catskill Water Supply. A general description. *Sept. 1915.* Gift of New York City Board of Water Supply.

New Jersey Board of Public Utility Commissioners. Financial and miscellaneous statistics compiled from the Annual Reports made by Public Utilities, 1913. *Union Hill, N. J. 1915.* Gift of New Jersey. Board of Public Utility Commissioners.

Results of Experiments on Sewer Pipe and Drain Tile, E. H. Beckstraud. Utah Engineering Experiment Station. Bulletin no. 7. *Salt Lake City, 1915.* Gift of E. H. Beckstrand.

Sound Steel Ingots and Rails, Sir Robert Hadfield and George K. Burgess. Reprinted from the Journal of Iron and Steel Institute, No. I, 1915. *London, 1915.* Gift of Sir Robert Hadfield.

Steam Boiler Economy, William Kent. Ed. 2. *New York, J. Wiley & Sons, 1915.* Gift of Publishers.

Fourteen years have elapsed since the issue of the first edition of Dr. Kent's book. Naturally this edition differs greatly from the former one. This is well shown by the author's summary of improvements in modern practice and the practical results obtained. The wealth of references makes this of especial value. W. P. C.

Ventilation of Subways and Subway Cars, Robert G. Klotz. *New York, 1915.* Gift of author.

Water Powers of Canada. Province of British Columbia, G. R. G. Conway. *Ottawa, 1915.*

———. The Prairie Provinces, Manitoba, Saskatchewan, Alberta, P. H. Mitchell. *Ottawa, 1915.* Gift of A. S. M. E.

Year Book of British Columbia and Manual of Provincial Information. Coronation Edition. *Victoria, 1911.* Gift of Sir Richard McBride.

### EXCHANGES

American Society of Civil Engineers. Constitution and List of Members, February, 1915. *New York, 1915.*

Engineers' Society of Western Pennsylvania. List of Members, October, 1915. *Pittsburgh, 1915.*

Municipal Engineers of the City of New York, Proceedings 1914. *New York, 1915.*

### TRADE CATALOGUES

American Blower Co. *Detroit, Mich.* Sirocco Service.

Chicago Pneumatic Tool Co. *Chicago, Ill.* Bulletin 216. "Hummer" self-rotating hammer drills. *Aug. 1915.*

Cleveland Twist Drill Co. *Cleveland, Ohio.* Drill Chips. *Sept. 1915.*

Flanner Water Tube Boiler Co. *Akron, Ohio.* Flanner Water Tube Boiler, description.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *Sept. 1915.*

Gardner Machine Co. *Beloit, Wis.* Gardner Grinder. *May-Aug. 1915.*

Lea-Courtenay Co. *Newark, N. J.* Catalogue H-2. Centrifugal Pumps.

Stephens-Adamson Mfg. Co. *Aurora, Ill.* Labor Saver. *Sept. 1915.*

Under-Feed Stoker Co. of America. *Chicago, Ill.* Publicity Magazine. *Sept.-Oct. 1915.*

Valley Iron Works Co. *Appleton, Wis.* The Beater. *Sept. 1915.*

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. *Sept.-Oct. 1915.*

Weston Electrical Instrument Co. *Newark, N. J.* Bulletin 2004. A. C. and D. C. Portable Voltmeters. *1915.*

——— 2002. Weston Portable A. C. and D. C. Wattmeters. *1915.*

——— 2003. A. C. and D. C. Portable Ammeters. *1915.*

## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

### ABRIDGED LIST OF OFFICERS AND COMMITTEE CHAIRMEN[1]

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House Committee, S. D. Collett

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Committee on Meetings, J. H. Barr

Committee on Membership, W. H. Boehm

Publication Committee, C. I. Earll

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Committee on Constitution and By-Laws, Jesse M. Smith

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*St. Louis:* Edward Flad
*Worcester:* Paul B. Morgan

[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal.

# THE JOURNAL OF
# THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 DECEMBER 1915 Number 12


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# THIRTY-SIXTH ANNUAL MEETING

New York City, December 7 to 10, 1915

## LIST OF TOPICS TO BE DISCUSSED

Abrasive Wheels
Accident Compensation
Automatic Machine Tools
By-Product Gas Producers
Chimney Proportions
Circulation in Boilers
Electric Elevators
Electrically-driven Tools
Engineer and Fire Insurance
Engineering and the Executive
Fire Tube Boilers
Foundations
Heating Textile Mills
Higher Steam Pressures
High Vacuum Condensers
Hydraulic Power Plants
Large Electric Plants
Locomotive Axles
Oil Engine Vaporizers
Orifice Gas Meters
Passenger Car Trucks
Prevention of Corrosion
Private vs. Purchased Power
Protection of Workers
Safety Methods
Safety Principles
Steam Pipe Coverings
Strength of Porcelain
Strength of Stoneware
Turbines vs. Engines

## LIST OF AUTHORS OF PAPERS

Dan Adams, Mem. Am. Soc. M. E.
Allen H. Babcock
Paul A. Bancel, Jun. Am. Soc. M. E.
J. S. Barstow
James E. Boyd
L. C. Brooks, Jun. Am. Soc. M. E.
L. D. Burlingame, Mem. Am. Soc. M. E.
Robert Cramer, Mem. Am. Soc. M. E.
F. W. Dean, Mem. Am. Soc. M. E.
Albert G. Duncan, Mem. Am. Soc. M. E.
Geo. H. Gibson, Mem. Am. Soc. M. E.
Hollis Godfrey, Mem. Am. Soc. M. E.
Ernest O. Hickstein, Jun. Am. Soc. M. E.
C. F. Hirshfeld, Jun. Am. Soc. M. E.
Louis Illmer, Mem. Am. Soc. M. E.
David Lindquist
Arthur H. Lymn
L. B. McMillan, Jun. Am. Soc. M. E.
Charles T. Main, Mem. Am. Soc. M. E.
Anatole Mallet, Hon-Mem. Am. Soc. M. E.
A. L. Menzin, Assoc-Mem. Am. Soc. M. E.
Mark A. Replogle, Mem. Am. Soc. M. E.
Frank W. Reynolds, Mem. Am. Soc. M. E.
Roy V. Wright, Mem. Am. Soc. M. E.

For program of the meeting see page VI.

## MEETINGS OF LOCAL SECTIONS

*December* 1, *St. Louis, Mo.* The President of the American Society of Engineering Contractors will address this Section.

*December* 1, *Buffalo, N. Y.* Subject: Internal Conveyors, by Fay B. Williams, Engineer of the Lamson Company.

*December* 15, *Buffalo, N. Y.* Subject: Engineers in Politics, by C. E. Drayer, Secretary of the Cleveland Engineering Society.

*December* 16, *Cincinnati, O.* F. L. Raschig will discuss the paper on Engineering Features of the Panama Pacific International Exposition by Guy L. Bayley, Mem. Am. Soc. M. E., using slides which Mr. Bayley made at the Engineering Congress at San Francisco.

*December* 16, *Minnesota.* Subject: Engineering Education in the British Isles, by John J. Flather. Dinner will be served at 6:30.

*December* 18, *St. Louis, Mo.* The Local Section of St. Louis will hold a dinner for the introduction of new members.

*January* 5, *Buffalo, N. Y.* Subject: The History of Iron, by Dr. J. A. Mathews, Mem. Am. Soc. M. E., of the Halcomb Steel Company.

*April* 11-14, *New Orleans, La.* Spring Meeting of The American Society of Mechanical Engineers.

THE JOURNAL OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Volume 37 December 1915 Number 12

# THE ANNUAL MEETING

THE thirty-sixth Annual Meeting will be held in the Engineering Societies building, 29 West 39th Street, New York, beginning on Tuesday, December 7, and ending on Friday, December 10. The attendance at annual meetings has been increasing steadily and last year's was the largest in the history of the Society. It is hoped that all members who find it possible to come to New York at the time of the meeting will do so, as this affords the greatest opportunity of the year for extending one's acquaintanceship. The Committee on Meetings has provided a program so varied that some part of it at least cannot fail to interest every member. The details of the program follow on another page, where the various professional papers are listed. Copies of these papers will be ready in pamphlet form in advance of the meeting, and any of them will be sent, free of charge, to any member asking for them previous to the time of the meeting.

Headquarters will be open for registration at 2 p.m. on Tuesday, December 7. In the evening the President, Dr. John A. Brashear, will give the annual address, on Science in its Relation to Engineering, followed by a reception to the President, Present-elect, ladies, members and guests. During his term as president Dr. Brashear has been very active among the membership. He not only has traversed the continent twice, but has made many other extended trips for the purpose of meeting members in different parts of the country. His lectures have delighted scores of audiences, and one of the anticipations of the present meeting is the pleasure of greeting and hearing Dr. Brashear at Tuesday evening's opening session.

### ENTERTAINMENT FEATURES

On Wednesday afternoon, December 8, a reception and tea will be given in the rooms of the Society to the visiting ladies, members and guests. This will be under the auspices of the Ladies Committee and is one of the delightful and important social features of the Annual Meeting. It is usual to close the afternoon with dancing. All are cordially invited to attend.

Special attention is called to the Smoker on Wednesday evening, which is to be held at the Society headquarters. This is distinctly a members' reunion, having for its chief function the opportunity to extend one's acquaintanceship and to secure to the fullest extent the benefits which come from time spent together in an assemblage of engineers from all sections of the country. No program is to be announced in advance, but the New York Committee gives every assurance of a good time. The usual Wednesday evening lecture of the Annual Meeting will this year be omitted.

The dinner and dance on Thursday evening will be held in the Grand Ball Room of the Hotel Astor. An attendance of over 400 is expected and the preparations for this event, which have been completed by the local committee, assure an event fully equal to the reunions of past years, which have been so important and successful a feature of the program. In view of the fact that the members in previous years have been very late in arranging for attendance at the Thursday evening reunion, the Committee has this year provided for a special price of $5 per person to all who purchase tickets before 6 P.M. on Wednesday, December 8. After this time, the price of the tickets for the dinner and dance will be $6 per person. Early notification with regard to purchase of tickets should be made at headquarters.

### EXCURSIONS

The plan this year will be to have a few excursions of exceptional interest rather than a multiplicity of less important trips. Visits are contemplated to the power and elevator plants of the Municipal and Woolworth buildings; to the 74th Street station of the Interborough Rapid Transit Company, where turbines of 40,000 h.p. are now running; and to the Brooklyn Navy Yard, where the battleship Brooklyn, designed to be the most powerful armorclad afloat, is under construction. A trip is also planned to one of New York's leading moving picture studios and to an aeronautical plant in the vicinity which is of interest.

# PROGRAM OF THE ANNUAL MEETING

*Tuesday Afternoon, December 7*

Conference of Local Sections, 12:30 p.m. All Council members and official delegates of the Society's fourteen sections will meet to discuss ways and means for making the local sections of the utmost benefit to the membership. Other conferences of local sections will be held at intervals during the convention.

Registration Bureau opens, 2 p.m.

Council Meeting, 2 p.m.

*Tuesday Evening*

Opening Session: Address by Dr. John A. Brashear, President of the Society, on Science in its Relation to Engineering.

Reception by the Society to the President, President-elect, ladies, members and guests.

*Wednesday Morning, December 8*

Business Meeting

Reports of the Council and Standing Committees. Constitutional Amendments. Report of Committee on Standardization of Special Threads for Fixtures and Fittings and announcement of Report of Power Test Committee. New Business.

Immediately following the business meeting, the Society will honor the memory of the late Dr. Frederick W. Taylor, Past-President. The proceedings will consist of a report by a special committee appointed by the President to represent the Society at the Taylor Memorial Meeting held in Philadelphia on October 22 under the auspices of the Society to Promote the Science of Management.

Professional Session

*Papers to be presented by title only*

Gas Producers with By-Product Recovery, Arthur H. Lymn

The Application of Engineering Methods to the Problems of the Executive, Director and Trustee, Hollis Godfrey, Mem. Am. Soc. M. E.

Modern Electric Elevator and Elevator Problems, David Lindquist

These three foregoing papers contributed by the New York local committee

Turbines vs. Engines in Units of Small Capacities, J. S. Barstow

Contributed by the Philadelphia local committee

The Connors Creek Plant of the Detroit Edison Company, C. F. Hirshfeld, Jun. Am. Soc. M. E.

Contributed by the Buffalo local committee

Proportioning Chimneys on a Gas Basis, A. L. Menzin, Assoc. Mem. Am. Soc. M. E.

The foregoing papers which are to be presented by title will be distributed at the meeting in pamphlet form, and written discussion upon them solicited for publication in The Journal. There will be no opportunity for oral discussion of these papers.

STEAM POWER

*Papers to be presented by abstract*

Design of Fire Tube Boilers and Steam Drums, F. W. Dean, Mem. Am. Soc. M. E.

Higher Steam Pressures, Robert Cramer, Mem. Am. Soc. M. E.

A Novel Method of Handling Boilers to Prevent Corrosion and Scale, Allen H. Babcock

This paper in preliminary form was presented before the San Francisco local section, December, 1914

*Wednesday Afternoon*

Simultaneous Sessions

RAILROAD

*Papers contributed by the Sub-Committee on Railroads*

Operation of Parallel and Radial Axles of a Locomotive by a Single Set of Cylinders, Anatole Mallet, Hon. Mem. Am. Soc. M. E.

Four-Wheel Trucks for Passenger Cars, Roy V. Wright, Mem. Am. Soc. M. E.

TEXTILE

*Papers contributed by the Sub-Committee on Textiles*

Heating by Forced Circulation of Hot Water in Textile Mills, Albert G. Duncan, Mem. Am. Soc. M. E.

Relative Value of Private and Purchased Electric Power for Textile Mills, Frank W. Reynolds, Mem. Am. Soc. M. E., and Dan Adams, Mem. Am. Soc. M. E.

MACHINE SHOP

*Papers contributed by the Sub-Committee on Machine Shop Practice*

Automatic Mechanical Control of Lathes and Screw Machines, L. D. Burlingame, Mem. Am. Soc. M. E.

Electric Operation and Automatic Electric Control for Machine Tools, L. C. Brooks, Jun. Am. Soc. M. E.

Report on Code for Abrasive Wheels.

During the afternoon a reception and tea will be given in the rooms of the Society to the visiting ladies, members and guests under the auspices of the Ladies' Committee. This will be one of the important social features of the Annual Meeting and all are cordially invited to attend.

Conference of Student Branches.

*Wednesday Evening*

SMOKER

A departure will be made from the usual Wednesday evening lecture, by holding a Smoker in the rooms of the Society. This will be a get-together, get-acquainted meeting, in charge of the New York local committee, to which every member is invited for a social evening and a good time.

*Thursday Morning, December 9*

Simultaneous Sessions

POWER PLANT

The Heat Insulating Properties of Commercial Steam Pipe Coverings, L. B. McMillan, Jun. Am. Soc. M. E.

Performance and Design of High Vacuum Surface Condensers, Geo. H. Gibson, Mem. Am. Soc. M. E., and Paul A. Bancel, Jun. Am. Soc. M. E.

Circulation in Horizontal Water Tube Boilers, Paul A. Bancel, Jun. Am. Soc. M. E.

Unique Hydraulic Power Plant at the Henry Ford Farms, Mark A. Replogle, Mem. Am. Soc. M. E.

MISCELLANEOUS

The Flow of Air Through Thin-Plate Orifices, Ernest O. Hickstein, Jun. Am. Soc. M. E.

This paper is the Junior Prize paper for 1915, and bears the further distinction of being the first paper to receive a prize from The American Society of Mechanical Engineers. A fund for Junior and Student prizes was recently established by a member of the Society.

Elasticity and Strength of Stoneware and Porcelain, James E. Boyd

Contributed by the Research Committee

Foundations, Charles T. Main, Mem. Am. Soc. M. E.
Contributed by the Sub-Committee on Industrial Building

Oil Engine Vaporizer Proportions, Louis Illmer, Mem. Am. Soc. M. E.

*Thursday Afternoon*

This afternoon is left free for excursions. Instead of providing for a large number of excursions, as in previous years, the Local Committee has arranged for a few of exceptional interest which it is expected large groups of members and guests will attend.

*Thursday Evening*

Annual Reunion, Dinner and Dance at Hotel Astor.

*Friday Morning, December 10*

Industrial Safety

Standardization of Safety Principles, Carl M. Hansen.

Other papers are expected to be presented on the following subjects: Modern Movement for Safety from Standpoint of Manufacturer; Methods of Reducing Accidents Through Coöperative Movements of Workmen; and Compulsory Compensation for Accidents by Law.

## ABSTRACTS OF PAPERS

In the November issue of the Journal brief abstracts were printed of the majority of the papers to be presented at the Annual Meeting. Below are given abstracts of four additional papers which are scheduled on the above program. These abstracts will furnish an idea of the contents of the papers and should be of assistance to members in selecting the papers of interest to them or for purposes of discussion.

### HEATING BY FORCED CIRCULATION OF HOT WATER IN TEXTILE MILLS

By Albert Greene Duncan, mem. am. soc. m. e.

This paper treats of the method of using hot water to heat, through direct heating surface, the various rooms of a large textile mill, the water being heated by live or exhaust steam in closed heaters in a central plant, and the hot water being distributed by forced circulation.

The regulation of heat in the various departments is in charge of the power plant engineer, long distance reading thermometers being installed in the power house.

Owing to the configuration of the plant, the heating system was installed in two sections, each section being taken care of by its own heater and pump, and there being a standby unit for emergency.

Since the installation of the system in 1912-13 extensive readings of temperature, humidity, amount of radiation in service, etc., have been made. These records bring out a number of interesting points and show:

*a.* The benefit of double windows in a plant offsets their cost many times.

*b.* Openings from heated rooms to entry ways and elevator shafts are a constant source of loss.

*c.* If study and regulation is made along proper lines, except in extreme weather, heating can be confined to the lower floors of a textile mill, to the weaving and carding departments and to portions of the mill where very little machinery is in operation.

### RELATIVE VALUE OF PRIVATE AND PURCHASED ELECTRIC POWER FOR TEXTILE MILLS.

By Frank W. Reynolds, mem. am. soc. m. e. and Dan. Adams, mem. am. soc. m. e.

Average rates for purchased power are higher by a small amount than the cost of generating power in a new isolated plant for a textile mill when there are no adverse conditions. The size of the plant and the load factor have little influence on the relative cost. A fair demand for steam in the process usually gives the isolated plant a decided advantage, but the use of steam for heating and for small demands such as slashing is relatively unimportant. The saving from the use of exhaust steam is apt to be overestimated unless the diversity factor and variable demand are studied carefully.

In the majority of new developments where reliable purchased power is available, the saving from private power will be too small to make the power plant investment attractive. The purchase of power does not wipe out existing fixed charges on a going plant, and therefore cannot compete in power cost with a plant already built, except in the case of additions or extensive renewals or very poor operating economy. The reliability of most purchased power is as good or better than that of an isolated plant without relay capacity.

In general, purchased power is desirable for textile mills, but the desirability must be weighed against the small additional cost in the average case.

### A NOVEL METHOD OF HANDLING BOILERS TO PREVENT CORROSION AND SCALE

By Allen H. Babcock.

The author gives an account of the difficulties experienced from corrosion in the boilers of the Fruitvale power house of the Southern Pacific Company, California, which were so serious that in 18 months one-third of the tubes required replacing. Various efforts were made to check the corrosion, without success, until the author learned of the investigations and experiments conducted by Commander Frank H. Lyon, U. S. N., on the treatment of feedwater. This work by Commander Lyon led to the proposal of a compound known as the "Navy Standard Boiler Compound," the main element of which is sodium carbonate, but which contains also trisodium phosphate, dextrine and a tannin compound; and a determination of the effect on corrosion of feedwater having different degrees of alkalinity. The compound was tried out at Fruitvale station with the result that corrosion troubles practically ceased.

A further trial of the compound was made, with favorable results, in one of the worst locomotive water districts on the Southern Pacific Lines, and also in other power plants of the system. An account is given of these experiences and of the modifications made to reduce foaming in locomotive boilers.

The paper outlines the features of the long investigation by Commander Lyon of the causes of corrosion and means for overcoming this trouble, which led to the discovery of the Navy compound. Full directions are given for using the Navy compound.

## PERFORMANCE AND DESIGN OF HIGH VACUUM SURFACE CONDENSERS

By Geo. H. Gibson, mem. am. soc. m. e.
and Paul A. Bancel, jun. am. soc. m. e.

Heat transmission in surface condensers presents anomalies of which a consistent explanation has not been offered. The coefficients of heat transmission secured in commercial condensers are far short of those realized in experimental laboratory condensers and, moreover, the coefficients obtained under summer conditions are always better than those obtained from the same condensers in winter, with colder circulating water. Examination of a number of tests of condensers with varying conditions shows, however, that the depression of the air pump suction temperature below the steam temperature corresponding to the vacuum is related to the average coefficient of transmission, or relative proportion of the active zone of condensation, in a definite way. This depression is due partly to fall in pressure and expansion of the steam incidental to its flow through the resistance presented by the condenser, and is also implied in the increasing partial pressure of the air as the latter nears the air pump suction opening. If the pressure at the inlet of the condenser is known and the drop can be calculated, the pressure at the air pump suction can be predetermined; and, taking into considerataion the fact that the virtual displacement of the air pump is approximately constant and that the air must therefore be reduced to a fixed volume regardless of vacuum, the temperature of the air pump suction with a given amount of air can be calculated. This, in connection with the inlet steam temperature is, as already mentioned, an indication of the average coefficient of transmission to be expected, which in turn makes it possible to estimate what water temperature will be necessary in order to carry the same load at a different vacuum, or vice versa. For a given condenser, the effects of changes in any of the following factors: load; vacuum; water temperature; rate of flow, and air pump capacity, can therefore be foretold if its performance under one set of conditions is known.

At high vacuums the spacing and the number of rows of tubes, which determine the pneumatic resistance of the steam flow path or paths, have great influence upon the average efficiency of the surface in transmitting heat. Since the controlling resistance is on the air-steam side of the tubes in the air-drowned inactive zone of the condenser, increase in water velocity is of little benefit in these tubes. In fact, this velocity may be decreased and the velocity in the tubes of the active zone increased where it will do some good without added power expenditure. Zone condensers of this kind are illustrated.

## COLLEGE REUNIONS DURING THE ANNUAL MEETING

It has been customary during the past few years for the New York Alumni Associations of various colleges where engineering courses are given to hold a reunion on the last evening of the Annual Meeting (which this year will be December 10), to welcome the large number of out-of-town alumni. Complete details of final arrangements will be given in the program distributed at the Annual Meeting. The following reunions have been planned tentatively for that evening:

### BROWN UNIVERSITY

The Engineering Alumni of Brown University will hold a reunion in the form of a Smoker. Those desiring to attend are requested to communicate with Mr. Francis P. Davis, care of American Telephone & Telegraph Co., 15 Dey St., New York.

### CORNELL UNIVERSITY

Mechanical Engineers from Cornell University have arranged for their annual dinner at the Cornell University Club, 65 Park Ave., New York. Definite details for the program have not yet been decided, but last year's plan of having appropriate special features for the entertainment of those in attendance will be carried out. Further information may be obtained from Mr. F. Kingsley, care of the Electric Railway Journal, 239 West 39th St., New York.

### LEHIGH UNIVERSITY

The New York Lehigh Club will hold an informal reunion dinner and smoker at the Machinery Club, Hudson Terminal Building, 50 Church Street, New York, at 6:30 P. M. Mr. Homer D. Williams of the Class of '90 will be the Guest of Honor. Further information may be had from Mr. H. H. Scovil, care of the Railway Steel Spring Co., 30 Church Street, New York.

### MASSSACHUSETTS INSTITUTE OF TECHNOLOGY

While no formal reunion has been arranged, the members of the Technology Club will go in a body to the Chemists' Club, 52 East 41st St., New York, where Dr. Richard C. MacLauren, President of Massachusetts Institute of Technology will make an address. On December 11 a luncheon and reception will be tendered to Dr. MacLauren at the Technology Club of New York, 17 Gramercy Park. All "Tech." men are invited to participate in these events. Information will be furnished by Mr. Thomars C. Desmond, 17 Gramercy Park, New York.

### POLYTECHNIC INSTITUTE OF BROOKLYN

The Mechanical Engineering Alumni of the Polytechnic Institute of Brooklyn will hold a reunion in the rooms of the Society. An invitation to attend is extended to all members of the Society as well as the Alumni of Polytechnic Institute. Detailed information may be obtained from Mr. H. G. Tyler, Polytechnic Institute of Brooklyn.

### PURDUE UNIVERSITY

The Purdue Club of New York will hold an informal reunion dinner and smoker at the Phi Gamma Delta Club, 34 West 44th Street, New York A number of celebrities are expected and all Purdue men are urged to attend. Further information may be obtained from Mr. J. B. Thiess, 463 West Street, New York.

UNIVERSITY OF ILLINOIS

The Alumni of the University of Illinois will hold a reunion dinner and smoker at the Chemists' Club, 52 East 41st Street, New York. Information may be obtained from Mr. J. A. Kinkead, care of the Parkesburg Iron Company, 30 Church Street, New York.

STEVENS INSTITUTE OF TECHNOLOGY

All members of The American Society of Mechanical Engineers and their guests are cordially invited to join with the Alumni of Stevens Institute of Technology in their annual dinner and theatre party on Friday evening, December 10, 1915, at the New Amsterdam Theatre, 42nd Street, west of Broadway. After the show, there will be a supper and dance at the Hotel Astor. Tickets may be obtained from the Tyson Company, Hotel Astor, and further information from Mr. B. Franklin Hart, Jr., 50 Church Street, New York.

WORCESTER POLYTECHNIC INSTITUTE

The New York Alumni of Worcester Polytechnic Institute will hold their Annual Dinner at 6 P. M. at the Hotel St. Dennis, Broadway and 11th Street, New York. Special features are being arranged to make this a "banner" event. Information may be had from Mr. Frank O. Price, Pratt Institute, Brooklyn, N. Y.

# REPORTS OF STANDING COMMITTEES

*Presented at the Council Meeting, November 12, 1915*

## REPORT OF THE COMMITTEE ON CONSTITUTION AND BY-LAWS

During the past year the Committee on Constitution and By-Laws has considered matters referred to it from the Council covering the following revisions:

B-27 A Nominating Committee of five members, not members of the Council, shall be appointed before February first of each year by the President. The Secretary shall publish the names of this Committee in the March issue of The Journal, together with a request to the voting membership of the Society that they recommend to the Committee the names of eligible persons for the elective offices to be filled at the next election. This Committee shall deliver to the Secretary in writing between the first and the fifteenth of June the names of its nominees for the various elective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of the Committee in the July issue of The Journal.

B-28 A special Nominating Committee, if organized, shall on or before October fifteenth, present to the Secretary the names of its nominees for the elective offices next falling vacant under the Constitution, together with the written consent of each nominee. The names of the nominees for the various offices proposed by this Committee shall be published by the Secretary under the names of this Committee in the November issue of The Journal.

Nominating Committee.

(Proposed) C-48 Special Nominating Committee:

Any group forming one per cent of the persons entitled to vote may constitute itself a Special Nominating Committee, with the same powers as the Annual Nominating Committee appointed by the President.

The proposed amendment to the Constitution was presented at the Spring Meeting in Buffalo and will come up for any suggested revision and amendment at the Annual Meeting in December.

The Committee has under consideration an amendment to By-Law 12 which the Council has requested be brought into harmony with the provisions for the nomination and balloting for officers of the Society.

By-Law 47 is a new By-Law for a uniform policy in the matter of reports of committees.

B-47 All written reports of all committees shall be presented to the Council. Each written report of every Committee must be approved in writing by at least a majority of the members of that Committee, before it is presented to the Council. A member of a Committee who disagrees with the action of a majority of that Committee may express his disagreement over his signature, either on the report of the Committee or in a minority report. The minority report of any member of a Committee if offered, shall be presented at the same itme that the report of that Committee is presented to the Council.

All reports of Committees must be first received by the Council who shall prescribe the manner in which they shall be presented to the Membership of the Society and be made public and printed.

The matter of professional reports has been further considered in a proposed amendment to C-54 of the Constitution to read as follows. This amendment was also presented at the Spring Meeting of the Society:

(Proposed) C-54 The Society shall claim the exclusive copyright to any reports of its duly appointed committees. The Council shall waive such copyright for specific reports. The Society shall copyright all papers read before the Society, printing thereon in each instance that the paper may be reprinted by anyone after the same has been read before the Society, provided that due credit be acknowledged to the Society and the author. The policy of the Society shall be to give the professional and scientific papers read before it the widest circulation possible, with the view of making the work of the Society known, encouraging engineering progress and extending the professional reputation of its members.

Rule 16 is obsolete and has been cancelled, provision being made for it in By-Law 33.

Rule 16—Ballots for amendments to the Constitution shall be canvassed and announced in the same manner as the ballots for officers of the Society.

F. R. Hutton, *Acting Chairman.*

## REPORT OF THE FINANCE COMMITTEE

Your Finance Committee reports that the income of the Society for the year ending September 30, 1915, was $147,628.60. The total expenditures chargeable to income were $118,846.79, leaving an excess over income of $28,781.81. Out of this excess it is necessary to reserve $2,000.00 for completing 1915 condensed catalogues, $100.00 for distributing Vol. 36, Transactions, $200.00 on account of expenses of San

Francisco meeting, leaving a balance of $26,481.81, which we recommend be turned into the Reserve Fund. It is further recommended that all appropriations in excess of actual expenditures be cancelled.

The expenditure of the Society per member for the fiscal year just closed is as follows:

| | |
|---|---|
| General Salaries | $ 2.24 |
| Rent, library, supplies, etc. | 1.73 |
| Committees on Membership and Increase of Membership | 1.00 |
| Sections | .56 |
| Employment Bulletin | .18 |
| Council contingencies | .17 |
| House Committee | .27 |
| Annual and Spring meetings | 1.24 |
| Year Book | .62 |
| Journal and Condensed Catalogue | 6.70 |
| Transactions | 1.77 |
| Other activities | 1.76 |
| Making a total of | $18.24 |

The Budget Appropriation for the current year equals per member approximately $20.50.

Your Finance Committee recommends the following budget for the year 1916:

| | |
|---|---|
| Finance Committee | $29,000.00 |
| Membership Committee | 2,000.00 |
| Council | 12,200.00 |
| Increase of Membership Committee | 6,000.00 |
| House Committee | 1,700.00 |
| Meetings Committee | 7,850.00 |
| Publications | 65,300.00 |
| Research Committee | 250.00 |
| Public Relations | 500.00 |
| Sales | 8,650.00 |
| Student Branches | 750.00 |
| Junior Prize | 100.00 |
| Total | $134,300.00 |

The estimated income for the year is placed at $149,570.00.

Appended will be found a report of the accounts of the Society as shown in the books for the fiscal year ending Sept. 30, 1915.

Respectfully submitted,

R. M. DIXON, *Chm.*,
W. H. MARSHALL,
A. E. FORSTALL,
} *Finance Committee.*

MR. R. M. DIXON,

CHAIRMAN, FINANCE COMMITTEE

Dear Sir: In accordance with your instructions, we have examined the books and accounts of The American Society of Mechanical Engineers, for the twelve months ended September 30, 1915.

The results of this examination are set forth in the three exhibits, attached hereto, as follows:

*Exhibit A* Balance Sheet, September 30, 1915.
*Exhibit B* Income and Expenses for the twelve months ended September 30, 1915.
*Exhibit C* Receipts and Disbursements for the twelve months ended September 30, 1915.

We hereby certify that the accompanying Balance Sheet is a true exhibit of its financial conditions as of September 30, 1915, and that the attached statements of Income and Expenses, and Receipts and Disbursements are correct.

Respectfully submitted,

WM. J. STRUSS & CO.,
*Certified Public Accountants.*

EXHIBIT A

BALANCE SHEET, SEPTEMBER 30, 1915

| | | |
|---|---|---|
| Equity in Society's Building (No. 25 to 33 West 39th Street) | $353,346.62 | |
| Equity in one-third Cost of Land (No. 25 to 33 West 39th Street) | 180,000.00 | |
| | | $533,346.62 |
| Library Books | 13,000.00 | |
| Furniture and Fixtures | 5,000.00 | |
| | | 18,000.00 |
| Stores, including plates and finished publications | | 16,128.02 |
| Trust Fund Investment | | |
| New York City 3½'s 1954 (par $45,000) | 39,696.81 | |
| St. Louis, Peoria & N. W. 1st 5's 1948 (par $10,000) | 10,613.89 | |
| United New Jersey Canal Co. (par $1000) | 970.00 | |
| City of East Orange, N. J., Temporary Loan | 20,000.00 | |
| Cash in Banks representing Trust Funds | 20,703 56 | |
| | | 91,984.26 |
| Cash in Banks for General Purposes | 19,504.00 | |
| Petty Cash, on hand | 500.00 | |
| | | 20,004.00 |
| Accounts Receivable | | |
| Membership Dues | 14,165.21 | |
| Initiation Fees | 2,150.00 | |
| Sales of Publications, Advertising, etc | 25,542.71 | |
| Total | | 41,857.92 |
| Advance Payments | | 1,292.50 |
| | | $722,613.32 |

LIABILITIES

| | | |
|---|---|---|
| Certificates of Indebtedness | | $54,100.00 |
| Trust Funds | | |
| Life Membership Fund | $43,500.00 | |
| Library Development Fund | 4,902.71 | |
| Weeks Legacy Fund | 1,957.00 | |
| Initiation Fee Fund | 38,358.90 | |
| Junior & Students Prize Fund | 2,000.00 | |
| Melville Fund | 1,055.85 | |
| Hunt Memorial Fund | 209.80 | |
| Total | | 91,984.26 |
| Dues Paid in Advance | | 676.24 |
| Initiation Fees, uncollected | | 2,150.00 |
| | | $148,910.50 |

| | | |
|---|---|---|
| Unexpended Appropriation 1913-14. | | 76 |
| Unexpended Appropriation 1914-15. | 1,163.21 | |
| Unapportioned Revenue 1914-15... | 27,618.60 | |
| | | 28,781.81 |
| Capital Investment............... | $497,246.62 | |
| Surplus and Reserve............ | 47,673.63 | |
| | | 544,920.25 |
| | | $722,613.32 |

### EXHIBIT *B*

Income and Expenses for the Twelve Months Ended September 30, 1915

| | | | |
|---|---|---|---|
| **INCOME** | | | |
| Membership Dues................ | | $88,892.87 | |
| Sales—Gross Receipts............ | | 10,612.99 | |
| Advertising ..................... | | 44,766.62 | |
| Interest and Discount............ | | 3,356.12 | |
| Total................ | | | $147,628.60 |
| **EXPENSES** | | | |
| Finance Committee | | | |
| Office Administration. | $18,269.34 | | |
| Occupancy Building.. | 3,600.00 | | |
| Library ............ | 3,990.53 | | |
| | | 25,859.87 | |
| Membership Committee. | | 1,842.34 | |
| Council | | | |
| Contingencies ....... | $1,432.29 | | |
| Local Sections........ | 3,390.01 | | |
| Employment Bulletin. | 1,193.82 | | |
| | | 6,016.12 | |
| Increase of Membership Committee. | | 4,644.62 | |
| House Committee................ | | 1,743.90 | |
| Meetings Committee.............. | | 8,248.50 | |
| Publication Committee | | | |
| Advertising ......... | $20,757.27 | | |
| Journal Text......... | 20,133.38 | | |
| Revises ............. | 278.00 | | |
| Transactions ........ | 11,744.12 | | |
| Year Book.......... | 4,026.06 | | |
| | | 56,938.83 | |
| Sales | | | |
| General ............. | $5,267.79 | | |
| Boiler Code.......... | 3,958.59 | | |
| Power Tests......... | 1,042.85 | | |
| | | 10,269.23 | |
| Research Committee.............. | | 20.76 | |
| Students' Committee.............. | | 532.72 | |
| Public Relations Committee....... | | 471.12 | |
| Junior Prizes.................... | | 5.13 | |
| John Fritz Medal................ | | 79.28 | |
| Engineering Congress............ | | 1,811.45 | |
| Society History.................. | | 362.92 | |
| Total................ | | | $118,846.79 |
| *Excess of Income over Expenses. | | | $28,781.81 |

* *Note:* Of this amount, to be reserved for

| | |
|---|---|
| Completing 1915 Condensed Catalogue... | $2,000.00 |
| Distributing Vol. 36, Transactions...... | 100.00 |
| San Francisco Meeting................ | 200.00 |
| Total........................... | $2,300.00 |

### EXHIBIT *C*

Receipts and Disbursements for the Twelve Months Ended September 30, 1915

| | | |
|---|---|---|
| Membership Dues................ | $80,887.95 | |
| Initiation Fees.................... | 16,940.00 | |
| Membership Dues, paid in advance.. | 705.19 | |
| Sales of Publications, Badges, Advertising, etc................. | 55,174.23 | |
| Interest ......................... | 4,592.69 | |
| | $158,300.06 | |
| Cash on Hand and in Banks General and Trust Funds, September 30, 1914.............. | 39,852.33 | |
| | | $198,152.39 |
| **DISBURSEMENTS** | | |
| Disbursements for General Purposes | $131,244.83 | |
| City of East Orange, N. J., Loan.. | 20,000.00 | |
| Certificates of Indebtedness Redeemed ..................... | 6,200.00 | |
| | $157,444.83 | |
| Cash on Hand and in Banks General and Trust Funds, September 30, 1915.............. | 40,707.56 | |
| | | $198,152.39 |

## REPORT OF HOUSE COMMITTEE

During the year the portraits of honorary members have been completed and hung in the rooms of the Society. The inventory of pictures, books, publications, stores and equipment has been brought up to date.

Sufficient funds have been saved from the Committee's appropriation to replace on an advantageous basis the worn-out typewriters with new ones, also to provide a metal fire-proof cabinet for the safe keeping of the card records of accounts of members.

Inasmuch as certain members have criticized the Society for not having a special room for out-of-town members to be used for special work, the Committee has provided for all conceivable present demands by the use of the Council room, and until greater demand is made for an additional room with the special purpose of serving out-of-town members, the Council room will be used for that purpose.

Plans have been prepared and estimates secured for the removal of partitions in rooms Nos. 1109 to 1112, so as to make one large room, providing more room and a more efficient arrangement for the members of the staff. Recommendations have been made to the Council for the necessary appropriations to execute this work.

Estimates have also been secured for enlarging the doorways between the elevator entrance corridor and the Council room, and the room adjacent to the Council room. Estimates have also been secured for re-decorating and re-arranging the elevator corridor of the Society.

It is believed these changes will add to the cheerfulness and usefulness of the Society's rooms.

The Society's property in charge of the Committee has been maintained to its previous high degree of permanency

in so far as the funds at the disposal of the Committee will permit.

| | |
|---|---|
| S. D. Collett, *Chmn.*<br>W. N. Dickinson<br>F. A. Scheffler<br>J. W. Nelson<br>O. P. Cummings | *House Commitee* |

## REPORT OF THE LIBRARY COMMITTEE

During the year ended September 30, 1915, there have been added to the library of the Society 775 volumes and 65 pamphlets. Two large collections have been presented to the Society; the first, the library of the late Horace See, Past President of the Society, a leading naval architect and marine engineer, was presented by John Philp, and comprises a large number of volumes on naval architecture and marine engines. The second, recently received as a gift from the widow of David N. Melvin, is the general library of a working engineer, especially strong in applied chemistry.

During the year the management of the library has been taken over by the United Engineering Society. All purchased books and periodicals will be the property of the United Engineering Society; gifts will be, as formerly, the property of the Founder Society to which the gift is made.

The United Engineering Society has established a Library Service Bureau, to have sole charge of the research work for out-of-town members. This Bureau, self-supporting, will conduct researches, make translations, copies and abstracts, at a charge covering the cost.

The Catalogue of Technical Periodicals in the Libraries of New York and vicinity has been published, as the first bibliographical contribution from the library, and has received favorable comment from engineers, librarians, and the technical press.

The attendance during the year was 12,749. The extension of the evening hour of closing from nine o'clock to ten o'clock has been welcomed by our readers.

During the year additional shelving to accommodate 20,000 volumes has been added; wooden cases for the storage of periodicals awaiting binding have also been purchased.

Respectfully submitted,

| | |
|---|---|
| Leonard Waldo, *Chmn.*<br>Jesse M. Smith<br>W. M. McFarland<br>J. W. Lieb<br>The Secretary | *Library Committee* |

## REPORT OF THE COMMITTEE ON MEETINGS

The Meetings Committee has met five times since the Annual Meeting of 1914, and will probably have several more committee meetings before the next Annual Meeting of the Society.

The movement inaugurated last year to complete the work of preparation for each meeting of the Society earlier than in former years has not been carried on with entire success, although some measure of progress has been achieved. It appears to be difficult to impress upon those not having had experience with meetings, the time necessary to pass upon, put in type, properly read proof and prepare illustrations for papers.

Three of the papers, out of five provided for the extra meeting in September were received late, and at a time when several members of the Meetings Committee and of the Society staff were not readily accessible, owing to the vacation habit. This situation made it necessary to put these papers in type before submitting them to the committee for approval and did not permit adequate time for revision. One paper which was deemed to need considerable revising could not be returned to its author for revision. The Editor did this work, but it is to be regretted that the author could not have been given an opportunity to do this himself. The time required for communication with San Francisco aggravated the situation in this instance.

A time limit should be fixed for receipt of papers from local committees and, upon its expiration, the Meetings Committee should proceed to complete the program, substituting for those expected, but not in hand other papers if necessary or desirable in its judgment.

The Annual Meeting for 1914 had the largest attendance in the history of the Society. The features of the convention were an all-day meeting on the general subject of the Engineer in Public Service, at which nine papers were presented through the efforts of the Public Relations Committee; a series of largely attended conferences for the discussion of the report of the Boiler Code Committee; and whole sessions by the Railroad and Iron and Steel Committees.

The Spring Meeting was held June 22 to 25, all sessions being held in Buffalo except that of Wednesday, June 23. This session, which included the business meeting, was held at Niagara Falls. Committee reports and professional papers were also presented at this session. On Wednesday evening an admirable illustrated address was delivered by Dr. F. H. Newell on The Engineer as a Citizen.

There were two simultaneous sessions Thursday morning for presentation of papers and a final one Friday forenoon.

The formal social feature was the reception and dance on Thursday evening, but the local committee provided in many other ways for the pleasure of the visiting members, their families and guests. The excellent arrangements for sightseeing and professional inspection trips at Niagara and in Buffalo contributed greatly to the success of the meeting.

In conformity with the other national societies a meeting was held in San Francisco preceding the International Engineering Congress and thirty-five of our members joined the party on the Engineers' special train for San Francisco. The committee was fortunate in securing two authoritative papers on the engineering features of the Exposition and the exhibits. Two papers were presented upon the oil engine, of general interest on the Pacific Slope, and one on the strength of gear teeth.

Plans are fairly well advanced at this time (September 1915) for the Annual Meeting to be held in December.

Enough papers are now in hand for four general sessions. A special session on Industrial Safety is to be arranged by the Sub-Committee on Protection of Industrial Workers. The Hon. John Price Jackson of that committee has consented to take the lead in arranging the program. The sub-committees on Machine Shop Practice, Textiles, and Railroads are each planning for sessions.

The sub-committees of the Meetings Committee have been reorganized. Two of these, for which there seems to be little work at present, have been discontinued, namely, those on Administration and Iron and Steel. In the case of some others, the chairman or other members have changed.

The Committee feels that special efforts should be made to

maintain the interest of engineers in the varied lines of work comprised in the membership and particularly of those who are so situated that their personal participation in the meetings is not practicable. The suggestion in this connection is submitted for consideration of the Council, that a larger number of papers be published by the Society, and that the publications may include some papers to be printed, with written discussion, which will be read by title only at the meetings. This will make it possible to place on record the results of research or analysis of permanent value, although the character of these papers may not be such as to make their oral presentation at a meeting of general interest to the membership at large. It is realized that this project involves larger expenditures, and owing to this the Meetings Committee does not venture to urge it upon the Council, but considers it a duty to present the question for consideration.

Respectfully submitted,

John H. Barr, *Chm.*,
H. E. Longwell,
H. L. Gantt,
R. H. Fernald,
L. P. Alford,
*Committee on Meetings.*

## REPORT OF COMMITTEE ON MEMBERSHIP

The Committee on Membership held nine meetings during the year 1914-1915.

The number of applications considered in the transaction of its work and a summary showing the action taken, follows:

| | |
|---|---|
| Applications pending Oct. 1, 1914 | 191 |
| Applications received during fiscal year | 1069 |
| Total | 1260 |

The following action was taken on these applications:

| | |
|---|---|
| Recommended for membership | 736 |
| Withdrawn for various reasons | 2 |
| Deferred indefinitely | 13 |
| Denied promotion | 3 |
| Deferred for special investigation | 14 |
| In regular course of procedure | 492 |
| Total | 1260 |
| Reinstatement deferred | 1 |
| Reinstatements and Reconsiderations pending | 11 |

Those recommended for membership were divided into the following gradings:

| | |
|---|---|
| Members | 271 |
| Promotion to Member | 23 |
| Associates | 38 |
| Associate-Members | 191 |
| Promotion to Associate-Member | 18 |
| Juniors | 195 |
| Total | 736 |

The reinstatement of nine members was recommended to the Council.

George A. Orrok, who was appointed a member of the Committee at the beginning of the year, found it necessary to resign and the Committee accepted his resignation with much regret. Dr. Charles E. Lucke accepted an appointment to serve the balance of Mr. Orrok's term, though it was necessary for him to make considerable personal sacrifice in order to serve the Society in this capacity.

Respectfully submitted,

W. H. Boehm, *Chmn.*
H. C. Meyer, Jr.
L. R. Pomeroy
Hosea Webster
Charles E. Lucke
*Membership Committee*

## REPORT OF THE PUBLICATION COMMITTEE

In the last annual report of the Publication Committee, there was a discussion of plans which had been proposed for eliminating the duplicate publication of papers in Transactions and The Journal. During the previous year The Journal had been published in a form whereby it could be bound at the end of the year and constitute the Transactions of the Society. At the same time, the advance papers for meetings were printed in pamphlet form as usual, for which the type was held to permit the publication of the annual volume of Transactions in the 6 by 9 library size.

In view of letters of criticism and suggestions received from the membership, it was evident that there was a very earnest desire on the part of many members to have the Transactions continued as a separate volume, and accordingly, by direction of the Council, Volume 36 was issued, leaving no break in the continuity in the series of these volumes.

The decision to issue Volume 36 of Transactions and the possibility of the continuance of Transactions led to a change in the presentation of matter in The Journal, in that the Annual and Spring meeting papers, which go to the entire membership in complete form in Transactions, and are available at all times in pamphlet form to those who desire them, have been condensed as published in The Journal. The Journal serves the purpose of a current periodical which contains accounts of meetings immediately after the meetings have been held.

On the other hand, the papers presented at local meetings of the Society, which, as a general thing, have not been included in Transactions, have had more complete publication in The Journal. Every effort has been made to render comprehensive reports of these local meetings.

The publication plan which has been followed the past year is as follows:

1. Advance copies of papers for Annual and Spring meetings printed in pamphlet form (6 by 9 size).
2. Very brief abstracts of these papers appear in The Journal previous to the meeting with the statement that pamphlet copies will be sent free to any member asking for them.
3. After the meeting a running account of the proceedings of the meeting is published in The Journal, which includes copious abstracts of the papers and discussion.
4. The complete papers for the Annual and Spring meetings are published in the annual volume of Transactions. When this volume is printed additional sheets are run on the press and bound up in pamphlet form as revises, which are placed in the stock room for future sales.
5. Papers presented at local meetings are published in The Journal in either abstracted or complete form.

The following resolutions have been adopted by the Com-

mittee and with the approval of the Council will constitute the policy of the Publication Committee for the ensuing year. It was moved that the Publication Committee recommend to the Council:

TRANSACTIONS

1. That the publication of the annual volume of Transactions be continued.
2. That it be published in the same size and binding as heretofore.
3. That it shall contain, subject to the approval of the Publication Committee, all of the papers and discussions presented at meetings of the Society (not including section meetings), and technical reports of Committees; and shall contain a syllabus of each paper, summarizing the essential facts and conclusions.
4. That it shall contain all the papers and discussions presented at section meetings which in the opinion of the Publication Committee are of sufficient merit.

REVISES

That additional revised copies of the papers and discussion be printed and bound in pamphlet form at the earliest practicable date. A charge will be made for such pamphlets.

ADVANCE PAPERS

That papers for the meetings of the Society be printed in pamphlet form in advance, as heretofore, and be sent to members gratis upon request, a notice of these papers with syllabi, being printed in The Journal one month before meetings.

THE JOURNAL

1. That The Journal be published monthly as heretofore, but with the view to making it a semi-monthly or a weekly as soon as the amount of matter to be handled requires it and funds for that purpose are available.
2. That the size of The Journal shall for the present remain as it now is.
3. That The Journal shall contain:
   *a* All of the papers and discussion presented at regular meetings of the Society, preferably in substantially complete form, or adequately abstracted, according to the character of the paper, as soon after the meetings as possible.
   *b* Papers, or abstracts, with discussion, presented at meetings of Local Sections.
   *c* Announcements and reports upon Society affairs and incidents, employment bulletin, library notes, personal notes, etc.
   *d* Department for contributed discussions on papers previously published, or new matter.
   *e* Members correspondence department, including suggestions on Society affairs.
   *f* Review of World's Technical Press.
   *g* Review of technical books, by experts selected by the Committee.

The Committee adopt as a policy that the Editor shall coöperate with the author to present all papers and discussions as concisely as possible, consistent with clearness and completeness. This not only adds to the utility of the paper, but will make possible the publication of more papers in complete form. An abstract should be done by the author. The editor will coöperate toward securing uniformity.

The practice has been to publish the papers in Transactions in full. In The Journal the present practice is to reduce the papers and discussion by abstracting about 50 per cent. To have published them complete in The Journal during the past year would have cost $3000 additional.

The Committee believes that the members will be best served by publishing papers in The Journal in substantially complete form, and that the additional cost of approximately $3000 would be fully justified by the enhanced value of The Journal.

The Committee, however, would make an exception of certain types of papers—notably voluminous research papers which may be more acceptably presented in abstract.

The point is often raised that there would be economy in printing The Journal and Transactions with the same size page to avoid the necessity of resetting the type. The 6 by 9 size is undoubtedly more acceptable to the members for Transactions and for the advance papers than the 9 by 12 size would be, and the 9 by 12 size is far more advantageous for The Journal, both on the score of greater income from advertising and lower cost of production.

An examination of the bills for the last volume of Transactions shows the additional cost per page for resetting the type to be $0.75. The cost for the total edition delivered to the members is $10.00 per page. The additional cost, therefore, for resetting amounts to 7½ per cent.

There are practical reasons, such as the wear of the type on a long run of The Journal and the uneven appearance of Transactions printed from worn type on which corrections have been made, and differences in the make-up of The Journal and Transactions which have a bearing on the matter and which should be considered as well as the cost.

A year ago, on account of depressed business conditions resulting from the war in Europe, it was anticipated that there might be a reduction in the income in advertising which would necessitate curtailment in the production of The Journal. These fears, however, have proved to be groundless since the year has proved to be the most successful one for The Journal and the income which has been turned back into the publication for the benefit of the membership has been the largest in its history.

An appropriation has been asked for printing an index to the first 30 volumes of Transactions this coming winter.

The following is a statement of the budget for the past year and of the actual income and expenses:

STATEMENT OF THE BUDGET FOR THE PAST YEAR AND OF THE ACTUAL INCOME AND EXPENSES

| | Budget for 1914-15 | | Actual Income | Actual Expenses |
|---|---|---|---|---|
| | Income | Expenses | | |
| Journal Text | .... | $21,000 | .... | $20,133.38 |
| Advertising | $40,000 | 18,600 | Cond. Cat. $20,690.64<br>Journal $24,075.98 | Cond. Cat. $7,705.28<br>Journal $15,051.99 |
| Transactions | .... | 11,000 | .... | 11,844.12 |
| Revises | .... | 500 | .... | 278.00 |
| Year Book | .... | 4,400 | .... | 4,026.06 |
| Total | $40,000 | $55,000 | $44,766.62 | $59,038.83 |

## REPORT OF THE RESEARCH COMMITTEE

I take pleasure in presenting the following report of the Research Committee of the Society for the year 1914-15.

The members of the Research Committee for the year have been as follows:

R. C. Carpenter, *Chairman*
R. H. Rice
R. D. Mershon
R. J. S. Piggott
A. M. Greene, Jr.

The Committee has held various meetings during the year, and has devoted a considerable amount of time to the promotion of various lines of investigation which have been referred to them, and has undertaken to stimulate further investigation by the appointment of sub-committees for special lines to work.

The Committee on Research was founded very largely as a result of efforts by the late C. W. Hunt, Past President of the Society. The first members were appointed by the late Col. E. D. Meier, Past President. The duty of the Committee as stated at the time of its appointment was to consist of work relating to the promotion of investigation, and of recording the results of investigation in the records of the Society where they would be useful for the engineering profession.

During the year the Committee has formulated concisely the field of work which it believes it should undertake, and in which there seems to be a demand for united effort, for the purpose of promoting investigations. As the result of careful consideration, the following statement as to the object of the Research Committee was agreed to unanimously:

> The object of the Research Committee is to promote the investigation of phenomena, operations or results of experiments concerning fundamental laws on which engineering practice may be based, and to place such data in permanent and basic form.

For the purpose of promoting investigation it was decided some years ago to form sub-committees consisting of eminent specialists in the particular subject under consideration, and this duty has constituted the principal activity of the Committee.

The following sub-committees have been appointed and all report progress in the particular field which has been referred for their consideration:

Sub-Committee on Fuel Oil

R. H. Danforth, *Chairman*
A. M. Hunt
L. E. Barrows
Ervin G. Bailey, resigned (accepted August 14); vacancy not filled

Sub-Committee on Materials of Electrical Engineering

R. D. Mershon, *Chairman*

Sub-Committee on Safety Valves

E. F. Miller, *Chairman*
P. G. Darling
H. D. Gordon
F. L. Pryor
F. M. White

Sub-Committee on Steam

R. H. Rice, *Chairman*
C. J. Bacon
E. J. Berg
W. D. Ennis
L. S. Marks
J. F. M. Patitz

Sub-Committee on Clinkering of Coal

L. S. Marks, *Chairman*
F. C. Hubley
A. V. Bleininger
O. P. Hood
O. W. Palmenberg
S. W. Parr

The appointment of other sub-committees is under consideration is as follows:

*Sub-Committee on an investigation of worm gearing.* F. A. Halsey has taken a great amount of interest in this and has already done a large amount of commendable work. This investigation will require a considerable amount of time and quite a large investment in order to carry it through properly. It is believed that arrangements will be made for carrying out this investigation under the leadership of Mr. Halsey, who is willing to devote his personal time to the investigation without compensation. A sub-committee has been suggested, but it has seemed desirable to await further developments before making definite appointments.

*Sub-Committee on Lubrication.* The appointment of this sub-committee has been urged by a letter to the Council by F. zur Nedden, and several other prominent members of the Society. The Bureau of Standards, Washington, D. C., has expressed a willingness to carry out investigations along this line, and for that reason the Research Committee believes that a large amount of valuable data and practical useful information can be secured. A paper on this subject was read before the Society by M. D. Hersey of the Bureau of Standards, which points out many promising lines of research open to investigation. The Committee on Research will without doubt appoint a sub-committee on Lubrication to coöperate with the Bureau of Standards.

*Sub-Commitee on Research Relating to Machine Tools.* This line of investigation was started some years ago by the National Machine Tool Builders Association in charge of a committee consisting of L. P. Alford, A. L. De Leeuw, J. B. King, E. R. Norris and Chas. Mills, and a considerable amount of money was expended in the building of a dynamometer. This association decided to abandon this line of technical investigation and recommended that the activity be transferred to The Am. Soc. M. E. Dr. Stratton, of the Bureau of Standards, has expressed a willingness and a desire to coöperate with The American Society of Mechanical Engineers in carrying out investigations along the line proposed by the technical committee relating to machine tools. It has been proposed to appoint as the sub-committee in charge of the machine tool investigation the members of the previous committee who are all connected with The American Society of Mechanical Engineers (which will include all excepting J. B. King) and to add to the commitee some member of the Bureau of Standards in order to get the advantage of the laboratory connected with the Bureau and also the advice and assistance of Dr. Stratton and others. Secretary Rice has already corresponded with Director Stratton as to the field of work which the Bureau of Standards and The American Society of Mechanical Engineers can take up jointly with good chances of success.

*Sub-Committee on Laboratory Equipment and Methods of Investigation.* The appointment of a sub-committee which should consist of the directors and scientific investigators in

the college and other laboratories has been proposed and is under consideration by the Committee. It is expected that a sub-committee with membership as stated above would be able to bring about coöperation of the various laboratory plants of engineering colleges and would result in scientific arrangement of laboratory research and ensure to the Society the results of investigations possible with the equipment and staff of such laboratories. It has been suggested that a meeting for such a sub-committee be called at the time of the coming Annual Meeting in December.

The Sub-Committee on Safety Valves has been the means of obtaining several papers on this subject which have appeared in the Transactions of the Society. The investigations made by Prof. E. F. Miller are notably of great value, and have formed the basis for standardizing the safety valve practice and construction, which was formulated as a result of very extended consideration by the Boiler Code Committee jointly with the manufacturers of safety valves.

R. D. Mershon has been actively engaged in obtaining data as to the strength of electrical engineering materials and has succeeded in getting the coöperation of Prof. Orton and Prof. Boyd of the Ohio State University at Columbus. The result of this investigation is a paper by Professor Boyd, which will be read at the Annual Meeting of the Society. This is believed to give the first reliable results of the strength of ceramic materials and adds valuable data to the records of the Society.

Prof. L. S. Marks has undertaken the important work of determining the character and amount of waste in the combustion of coal which results in the production of clinkers. His sub-committee reports progress. During the coming year, I believe a considerable amount of useful data will be obtained which will serve as a basis of extended papers before the Society.

The Research Commitee is hampered to a considerable extent by the fact that the fund available for promotion of investigation is small, and it has not been considered desirable to undertake any line of work, no matter how desirous or how promising, because of the need of financial backing, which was not, under present conditions, assured.

The Committee expresses confidence that at some time in the future funds may be available for the expense of promoting investigations and for making proper records and deductions from such investigations, which can be put in a condition available for the practical guidance of engineering construction.

Respectfully submitted,
Rolla C. Carpenter, *Chairman.*

## REPORT OF PUBLIC RELATIONS COMMITTEE

The Standing Committee on Public Relations was first appointed about 1910, following the Washington Meeting at which the Constitution was amended to make provision therefor. It would appear that for the first few years after appointments were made no special action was taken by the Committee, although there were during this period some minor references made to it by the Council.

An appropriation of $500 was made for the first time this year to cover the activities of the Committee. Following out the evident desires of the Society as shown by this Committee, a Public Service Session was planned and held in connection with the Annual Meeting in New York in 1914. This session was addressed by his Honor the Mayor of New York, John Purroy Mitchell; by the then President of the Society, James Hartness, and by the President-elect, John A. Brashear, and by Andrew Carnegie. The following papers covering various parts of the field of Municipal Engineering were presented and ably discussed:

The Future of the Police Arm from an Engineering Standpoint, by Henry Bruere
Snow Removal, by Intercity Committee on Snow Removal
The New Charter for St. Louis, by Edward Flad
The Engineer and Publicity, by C. E. Drayer
The Handling of Sewage Sludge, by George S. Webster
Some Factors in Municipal Engineering, by Morris L. Cooke
Training for City Employes in the Municipal Colleges of Germany, by Clyde Lyndon King
The Design and Operation of the Cleveland Municipal Electric Light Plant, by Frederick W. Ballard
A Study of Cleaning Filter Sands with no Opportunity for Bonus Payments, by Sanford E. Thompson.

The attendance at this session, the interest shown by the discussion and the demand there has been for the papers presented, all demonstrate that in carrying out this plan, a valued public service was rendered.

During the year a number of important references from the Council have been acted upon. The whole drift among engineers individually and as members of technical societies is toward a larger participation in public affairs. There are certain classes of activities that apparently fall clearly within our field and which we should undertake—activities which will be carried on by those poorly qualified to handle them if our profession fails to meet its opportunities. On the other hand, demands for our coöperation in increasing number will be made upon us that should be just as clearly declined. Without more experience than we have thus far had, it would be premature to make any hard and fast rules in this connection.

Among the subjects which have received favorable report of your Committee and which have later been endorsed by Council, are the participation by our Society in the activities of a joint inter-technical society committee to study the question of expert testimony and the methods under which it should be given. We also advised the appointment of delegates from our Society to serve on a joint committee made up of representatives from different engineering societies to assist the National Government in preparations for the engineering branch of a military reserve. The Committee under the able chairmanship of William Barclay Parsons has been in constant conference with the national authorities for months past. Delegates have also been appointed to serve on a board of engineers which made suggestions on engineering matters to the New York State Constitutional Convention.

It is believed by your Committee that if our Society can take up such lines of activity in fields obviously our own that we may develop methods of service of benefit to our Government—federal and state—as well as to the profession. To withhold such activity on narrow grounds would appear to be ill-advised.

Morris L. Cooke, *Chmn.*
George M. Brill
James Mapes Dodge
Spencer Miller
Worcester R. Warner
*Public Relations Committee*

## COUNCIL NOTES

At the meeting of the Council on November 12, 1915, the following members were present: John A. Brashear, *President*, H. L. Gantt, R. M. Dixon, *Chairman, Finance Committee*, D. C. Jackson, A. M. Greene, Jr., Henry Hess, Spencer Miller, James E. Sague, Frederick R. Hutton, William H. Wiley, *Treasurer*, C. T. Main, E. E. Keller, and Calvin W. Rice, *Secretary*.

A special order of business was the consideration of the report of the Administration Committee. After an extended discussion, the Committee was invited to take into consideration the various suggestions of the members of the Council, and to frame recommendations in accordance with the views expressed.

The reports of the Standing Committees were presented and were ordered printed in this issue of The Journal and distributed at the Annual Meeting.

The appointment was announced of Ambrose Swasey as the representative of the Society at the Pan-American Scientific Congress and W. H. Marshall as alternate, in response to the invitation of the Department of State of the United States; and the announcement was made of the selection by the Secretary of State of Dr. John A Brashear as the representative of the engineering profession in America to the Congress. E. M. Herr was appointed as the Society's representative at the celebration of Carnegie Day, November 23, commemorating the eightieth birthday of Mr. Carnegie.

Prof. Frederick R. Hutton presented a copy of the Society History, and announced the completion of its publication. A vote of thanks was tendered to him and to those who had assisted him in its preparation.

Interpretations of the Boiler Code were on motion received, ordered issued and published in The Journal.

The appointment of E. Howard Reed as Chairman of the Worcester Committee on Increase of Membership was confirmed.

It was voted to receive the report of the Committee on Threads for Fixtures and Fittings. This report will be printed and distributed and open for discussion at the business session, Wednesday morning, of the Annual Meeting.

It was voted to approve the exchange of house and library privileges with the Engineers' Club of Kansas City.

Calvin W. Rice,
*Secretary.*

## AN EMINENT PENNSYLVANIAN

[Editorial from The Pittsburgh Gazette]

In the proposal by a group of prominent Pittsburghers to honor the 75th birthday anniversary of John A. Brashear on November 24, there is exhibited a fitting sense of the long and valuable services of this truly eminent citizen of Pittsburgh and of the State of Pennsylvania. To be the chief guest at a banquet is not an uncommon mark of distinction or of friendship, but in any effort, great or small, to honor Dr. Brashear, there will enter an element of universal approval that sets it apart from any like demonstration. As a scientist, as a citizen and as a brother to all men, John A. Brashear holds a peculiar place in the history of Pittsburgh and in the affection and esteem of his fellow citizens. His rise from obscurity to a place of authority and world-wide usefulness in the field of astronomical invention, and the story of his early struggles and patient endeavor to overcome the obstacles in his path, are parts of the history of Pittsburgh of which every man, woman and child, perhaps, has read and is proud.

His amiability, his thousand unheralded acts of philanthropy and his benign, cheery disposition are things that his more intimate friends know. He is "Uncle John" to hundreds of people still obscure in life and the simplicity and democracy of his association with his fellowmen have won him the deepest affection of old as well as young. To give John A. Brashear a banquet seems, in view of all that he is and has done for the world, a trivial compliment to a great man, but it carries with it the affectionate hope that the 75th anniversary of his birth may find him hale, happy and hearty and with many more ripe and peaceful years in which to enjoy the companionship of those who love him for the man he is and honor him for the service he has given to the city, the state and the world.

## NAVAL CONSULTING BOARD

The second meeting of the civilian Naval Consulting Board took place in New York City on November 4, when the board was divided into sixteen Committees, each to deal with its own special problems. The names and personnel of these committees are as follows:

Chemistry and Physics. W. R. Whitney, *Chairman*, Lawrence Addicks, L. H. Baekeland, Joseph W. Richards, M. B. Sellers, A. G. Webster, R. S. Woodward.

Aeronautics, Including Aero Motors. Henry A. Wise Wood, *Chairman*, Howard E. Coffin, P. C. Hewitt, Andrew L. Riker, M. B. Sellers, E. A. Sperry, A. G. Webster.

Internal Combustion Motors. Andrew L. Riker, *Chairman*, Howard E. Coffin, M. B. Sellers, E. A. Sperry.

Electricity. Frank J. Sprague, *Chairman*, Lawrence Addicks, William Le Roy Emmet, P. C. Hewitt, B. G. Lamme, A. G. Webster.

Mines and Torpedoes. Elmer A. Sperry, *Chairman*, L. H. Baekeland, M. R. Hutchison, Hudson Maxim.

Submarines. William Le Roy Emmet, *Chairman*, A. M. Hunt, M. R. Hutchison, W. L. Saunders, Frank J. Sprague.

Ordnance and Explosives. Hudson Maxim, *Chairman*, L. H. Baekeland, A. M. Hunt, M. R. Hutchison, Frank J. Sprague, A. G. Webster, W. R. Whitney, Henry A. Wise Wood, R. S. Woodward.

Wireless and Communications. P. C. Hewitt, *Chairman*, A. G. Webster, W. R. Whitney.

Transportation. Benjamin B. Thayer, *Chairman*, Howard E. Coffin, Alfred Craven, Spencer Miller, A. L. Riker, Thomas Robins, W. L. Saunders, Henry A. Wise Wood.

Production, Organization, Manufacture and Standardization. Howard E. Coffin, *Chairman,* Lawrence Addicks, William Le Roy Emmet, B. G. Lamme, Thomas Robins, W. L. Saunders, Benjamin B. Thayer.

Ship Construction. Frank J. Sprague, *Chairman,* Spencer Miller, Joseph W. Richards, Henry A. Wise Wood.

Steam Engineering and Ship Propulsion. Andrew M. Hunt, *Chairman,* William Le Roy Emmet, B. G. Lamme, Joseph W. Richards, M. B. Sellers.

Life Saving Appliances. Spencer Miller, *Chairman,* Hudson Maxim, Thomas Robins.

Aids to Navigation. Elmer A. Sperry, *Chairman,* Alfred Craven, A. M. Hunt, Henry A. Wise Wood, R. S. Woodward.

Food and Sanitation. L. H. Baekeland, *Chairman,* Hudson Maxim, Benjamin B. Thayer, W. R. Whitney, R. S. Woodward.

Public Works, Yards and Docks. Alfred Craven, *Chairman,* Lawrence Addicks, A. M. Hunt, Spencer Miller, Joseph W. Richards.

Dr. M. R. Hutchison, Mem. Am. Soc. M. E., of Llewellyn Park, West Orange, N. J., has been appointed on the Board by Secretary Daniels. He is included above in the Committees on Submarines, Mines and Torpedoes, and Ordnance and Explosives.

## INTERNATIONAL ENGINEERING CONGRESS

The volumes of Transactions of the International Engineering Congress, shortly to be issued, will be worthy of a place in the library of any member of the Society. Many of the papers are monumental, and the scope of practically each one is a review of recent signal work in the field to which it relates, as well as a discussion of the lines of future development. Collectively, the papers therefore represent the status of engineering in 1915. Many of them contain bibliographies of their subjects, which are invaluable for reference purposes.

The Committee of Management of the Congress reports that, on October 1, over 3,500 engineers and others had subscribed for volumes, and that subsequently 1,500 had ordered an average of 2.25 extra volumes each.

The Congress now extends an invitation to any who have not yet done so to subscribe to one or more of the volumes of Transactions of which there are eleven, as follows: The Panama Canal, Waterways and Irrigation, Municipal Engineering, Railway Engineering, Materials of Engineering Construction, Mechanical Engineering, Electrical Engineering and Hydroelectric Power Development, Mining Engineering, Metallurgy, Naval Architecture and Marine Engineering, Miscellaneous, including Aeronautics, Refrigeration, Agricultural Engineering, Engineering Education, Heating and Ventilation, Scientific Management.

Each volume is complete in itself and may be subscribed for separately, or a number of volumes or complete sets may be obtained. The contents of the volumes are substantially as given in the September number of The Journal, in which an advance program of the Congress was published. A subscription form which may be used when ordering volumes is given in the advertising section of this issue.

The Congress was organized and conducted under the auspices of the American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, Society of Naval Architects and Marine Engineers, and this Society.

## CONGRATULATIONS TO PHILADELPHIA

Philadelphia, always dominant in engineering, has now demonstrated that her engineers are supreme as engineers of men as well as of things. During five days of the past month, the members of the Engineers Club of Philadelphia conducted a whirlwind campaign for new members. Starting with a membership of 551, it was expected that 1000 new members would be added. A corresponding reduction in dues was planned, based on a sliding scale in proportion to the number of members. Quoting from the Philadelphia Ledger:

> The red paint that fills the immense thermometer in the Engineers' Club, marking the progress of the club's campaign for new members, who are to make Philadelphia the engineering center of the East, splashed over the thermometer's top yesterday, and the campaign, with 24 hours yet to go, was pronounced a huge success. In four days the club had recruited 990 new members, raising its total membership to 1541. Another record was broken in membership campaigns yesterday, when 331 technical men joined the organization. The campaigners were so enthused with their success that they set themselves a new goal. By noon to-day they expect the total of new members will reach 1250.

And this total was not only reached, but far exceeded. At the end of the five days 1672 members were added, making a grand total of 2,223. This is the largest membership of any Engineers' Club in the country, exceeding that of the Engineers' Club of New York by over 100, and resulting in a prospective reduction of dues from $35 to $15 per year. Many members of the local sections of the national societies are also members of the Engineers' Club, indicating the spirit of coöperation which exists. The sections represented include The American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, the American Society of Illuminating Engineers, the local body of the Society of Automobile Engineers, and the local Technology Club of the Mass. Inst. of Technology.

## INAUGURATION AT LAFAYETTE

Dr. John Henry MacCracken, former syndic and professor of politics, New York University, and an educator in philosophy, was inaugurated president of Lafayette College on October 19. The Society was represented at the exercises by William R. Dunn, Mem. Am. Soc. M. E., and two hundred colleges sent delegates.

The programme included a conference on Educa-

tional Problems of Lafayette College, an inaugural dinner, an academic procession and the conferring of nineteen honorary degrees.

## REPRINT OF REPORT OF JOINT COMMITTEE ON STANDARDS FOR GRAPHIC PRESENTATION

Owing to the heavy demand for copies of the Report of the Joint Committee on Standards for Graphic Presentation, a second edition of the reprint of the Report as it appeared in the Journal of August, 1915, page VII, became necessary. As a result, the Report has been reprinted in the form of a 6 x 9 inch pamphlet of 8 pages, in which the illustrations have been remade to a uniform size and somewhat larger, to facilitate study of the diagrams and reproductions therefrom. The price of the pamphlet remains at 10c. per copy.

## PROMULGATION OF THE BOILER CODE BY THE AMERICAN UNIFORM BOILER LAW SOCIETY

For the purpose of cooperative effort, leading to the introduction of the Boiler Code formulated by the Boiler Code Committee of the American Society of Mechanical Engineers early this year, an organization has recently been formed under the name of The American Uniform Boiler Law Society. This society, which has ambitious plans for extending its work into every state in the Union, is composed of representatives of all the industries connected in any way with steam boiler construction or operation. These industries and the men representing them are as follows:

| | |
|---|---|
| Tubular Boilers | Thomas E. Durban |
| American Boiler Manufacturers Assc'n | E. R. Fish |
| National Assc'n of Thresher Manufacturers | H. P. Goodling |
| National Boiler & Radiator Manufacturers Assc'n, | F. W. Herendeen |
| Low Pressure Steel Boiler Manufacturers | M. F. Moore |
| Water Tube Boiler Manufacturers | I. Harter, Jr. |
| Locomotive Manufacturers | John Wynne |
| Steam Shovel Manufacturers | Walter Plehn |
| Hoisting Engine Manufacturers | H. N. Covell |
| Boiler Insurance Companies | Chas. S. Blake |
| National Electric Light Assc'n | John Hunter |
| Boiler Materials | D. J. Champion |

The above representatives form the administrative council of the Society, of which Thomas E. Durban has been appointed chairman. In order to defray the expenses incurred in the work of promulgation, an annual subscription, in varying amounts, has been made by the above industries through their representatives, amounting in total to $12,000. It is proposed to expend at least this amount annually in the effort to secure uniformity of boiler laws throughout the United States and neighboring countries.

The council and chairman are anxious at all times to receive suggestions emanating from any source whatever, and are desirous of obtaining the moral support of everybody interested in the Code, as they feel that this moral support is fully as important as is the financial support. They ask for earnest and sincere cooperation and advice.

In entering upon its activities, the Society held a meeting late in the summer, for organization and a proper division of the work and the voluminous business arranged for. The chairman, Mr. Durban, was authorized to personally visit the legislative representatives and industrial bodies in a number of states, and as a result considerable progress has been made during the early fall months. The chairman made a trip to the Pacific Coast, upon which he was able to meet with the executive committee of the Uniform Law Association in Salt Lake City, the Commission of Public Safety in California, the Commission of Labor in Oregon and the legislative representatives in Washington and Minnesota. Similar activities have been taken up in a large number of the remaining states by other members of the administrative council and definite progress in the matter of moulding public opinion is reported in both the lower Eastern tier of states and in New England.

The states that now recognize the Boiler Code of The American Society of Mechanical Engineers are Wisconsin, Indiana, Ohio, Pennsylvania and California, the last state having but recently established the Code under the authority of the Department of Public Safety. It is also to be noted that the Boiler Code of The Am. Soc. M. E. is in use as the standard code of the Boiler Inspection Department of the cities of Detroit and Chicago. Several other states are undertaking to adapt their boiler inspection departments to the requirements of the Code and some of the boiler insurance companies, notably the Hartford Steam Boiler Inspection and Insurance Company and the Fidelity & Casualty Co., have officially adopted the Boiler Code of The Am. Soc. M. E. as their standard for new boilers throughout all parts of the United States.

In important cooperative movement in the introduction of the Code in the legislative channels in the various states is the recognition given at a recent meeting by the National Electric Light Association, in the approval of the action of The American Uniform Boiler Law Society in its work. This association appointed Mr. John Hunter, member of the Council of The Am. Soc. M. E., as its representative to serve on the administrative council of The American Uniform Boiler Law Society, and it is expected that he will be particularly able in securing the cooperation of member companies in the various states.

An interesting indication of the universal applicability of the Boiler Code is to be seen in its adoption by representatives of the Argentine Republic, as specifications covering all orders recently placed in this country for boilers to be shipped to them. In the specifications of Direccion General Explotacion del Petroleo de Comodoro Rivadavia, 278 Balcarce, Buenos Aires, S. A., the following is stipulated:

Each of the boilers under the items covered by Article I is to have a total heating surface to develop the rated horse power as indicated under Items for each boiler, based upon the evaporation of $34\frac{1}{2}$ lb. of water per h.p., at and from 212 deg. fahr. Boilers will be built for a working pressure of 150 lb. per sq. in. and to general design and in strict conformity with the requirements of The American Society of Mechanical Engineers' Boiler Code, issued 1914.

Similarly, it has recently been reported that the Code has been made acceptable in the city of Manila, P. I., and efforts are being made to bring the matter of adoption of the Code in the entire Archipelago before the Philippine legislature which is soon to meet. The interests of the Code there are being promoted by Mr. Frank L. Strong, of Manila, P. I.

## SECOND PAN-AMERICAN SCIENTIFIC CONGRESS

Announcement is made of the Second Pan-American Scientific Congress which will be held in Washington, D. C., December 27, 1915 to January 8, 1916. The headquarters of the meeting will be at the Pan-American Union in Washington, and it will be under the direction of John Barrett, LL.D., secretary general of the Union, and Glen Levin Swiggett, Ph.D., assistant secretary general.

The program of the Congress is divided into nine sections which, with the names of the Chairman in charge, are as follows:

I. Anthropology, William H. Holmes, B.S., Smithsonian Institution, Washington, D. C.

II. Astronomy, Meteorology, and Seismology, Robert S. Woodward, Ph.D., Carnegie Institution, Washington, D. C.

III. Conservation of Natural Resources, Agriculture, Irrigation and Forestry, George M. Rommel, B.S., Bureau of Animal Industry, Department of Agriculture, Washington, D. C.

IV. Education, P. P. Claxton, LL.D., Bureau of Education, Washington, D. C.

V. Engineering, W. H. Bixby, Mem. Am. Soc. M. E., Brig. General U. S. A., Retired, Washington, D. C.

VI. International Law, Public Law, and Jurisprudence, James Brown Scott, A.M., J.U.D., LL.D., Carnegie Endowment for International Peace, Washington, D. C.

VII. Mining and Metallurgy, Economic Geology, and Applied Chemistry, Hennen Jennings, C.E., Washington, D. C.

VIII. Public Health and Medical Science, William C. Gorgas, M.D., Sc.D., Surgeon General U. S. A., Washington, D. C.

IX. Transportation, Commerce, Finance, and Taxation, L. S. Rowe, Ph.D., President, American Academy of Political and Social Science, Philadelphia, Pa.

Some of the Sections are divided further into Sub-Sections. There are forty-five of the latter in all, each with a special committee and program. The deliberations of the Congress will be based according to the subject-matter to be discussed in the various Sub-Sections. There will also be general sessions of the Congress as a whole. The various Sub-Sections of the Congress may arrange for joint sessions. There will also be joint sessions between certain Sections of the Congress and national Associations which may be meeting in Washington at the time of the Congress.

The following persons will be members of the Congress:

*a*. The official delegates of the countries represented.

*b*. The representatives of the universities, institutes, societies, and scientific bodies of the countries represented.

*c*. Such persons in the countries participating in the Congress as may be invited by the Executive Committee, with the approval of the countries represented.

*d*. All writers of papers.

Upon invitation from the Congress, Dr. John A. Brashear, President Am. Soc. M. E., and Ambrose Swasey, Past President Am. Soc. M. E., have been appointed as delegate and alternate, respectively, to the Congress.

The Committee of this Society coöperating with the Department of State in the conduct of the Congress consists of

GEN. W. H. BIXBY, *Chairman*.
PROF. CARL C. THOMAS
CHARLES T. PLUNKETT
S. W. STRATTON
CALVIN W. RICE, *Secretary*

All members interested are invited to communicate with the Secretary.

## LOCAL SECTIONS CONFERENCE

One of the most important features of the Annual Meeting will be the series of conferences to be held by the Chairman of the fourteen local sections of the Society and delegates from various localities interested in the establishment of sections. The opening session of the conference will take place at noon Tuesday, December 7 and continue throughout the entire afternoon, enabling the delegates to give their individual attention to the matter. The Council has been invited to meet with the delegates at the opening conference in order to give opportunity for exchange of ideas with the representatives of Sections.

The Society considers this conference of great importance to its development and to ensure a full attendance of delegates arrangements have been made to pay the railroad fare of the chairman of each section to the meeting. The policy of the Society is to encourage the members of any locality where there are a sufficient number, to organize a section for conducting professional meetings and developing the Society there. Coöperation will be offered in such cases by granting an appropriation to cover the expenses of conducting

meetings, and assist in securing prominent speakers to address the members. Papers of value before sections will be published in full or in abstract in The Journal.

One fact which is emphasized is that in no case is the establishment of a section in a city where a local engineering society already exists an indication that the Society is entering into competition with that organization. Quite the contrary, the Society wishes in every instance to work hand in hand with the local Society or Club and hold joint meetings whenever possible. However, in practically all centers where local engineering organizations exist, there are a number of Am. Soc. M. E. members who are not members of the local society and therefore not enjoying the benefits of meetings and reunions, and it has been found by experience that the establishment of Sections of the Society in such places not only serves those who belong to the Am. Soc. M. E. only, but also strengthens the local organization and works to the mutual benefit of both groups and the community.

### CONFERENCE OF STUDENT BRANCHES

The thirty-eight Student Branches of the Society have been invited to each send a delegate to attend a Conference of Student Branches to be held during the Annual Meeting. They will meet in the rooms of the Society Wednesday afternoon, December 8, from four to six o'clock, to discuss matters of importance in connection with the Student Branch work. The Committee on Student Branches, of which Professor F. R. Hutton is Chairman, will have charge of this meeting. It is expected to have ready for distribution a brochure setting forth the advantages of student membership and the reasons why every student of mechanical engineering should affiliate with the national society. It points out that the student obtains valuable experience in not only conducting meetings but in extemporaneous speaking and in the preparation and presentation of technical papers, and also in numerous other ways. This Conference will, it is hoped, have a stimulating effect on the development of Student Branch activities.

# APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON JANUARY 10, 1916.

Members are requested to scrutinize with care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages would qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of grading are also posted.

*The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned.* All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The candidates will be balloted upon by the Council unless objection is received by January 10, 1916.

### NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Barnhurst, Henry G., Mech. Engr., Fuller Engrg. Co., Allentown, Pa.

Bellinger, Daniel L., Ch. Mech. Engr., Finch, Pruyn & Co., Glens Falls, N. Y.

Bent, Stedman, With Phoenix Iron Wks. Co., Meadville, Pa.

Crawford, Chauncey H., Asst. Engr., Mech. Dept., Nashville, Chattanooga & St. Louis Rwy., Nashville, Tenn.

Flowers, Alan E., Prof. of Elec. Engrg., Ohio State Univ., Columbus, O.

Gilbert, Ernest M., Mech. Engr., Wm. P. Bonbright & Co., Inc., New York

Gillespie, William K., Asst. Mech. Engr., Canadian Steel Foundries Ltd., Montreal, Canada

Guthrie, James, Automobile Engr., Briscoe Freres, Jackson, Mich.

Jay, Edward G., Jr., Engr. and Mgr. Meter Dept., Yarnall-Waring Co., Philadelphia, Pa.

Knopf, George W., Asst. Mgr., McClintic-Marshall Construction Co., Pottstown, Pa.

McCoy, Francis N., Master Mech., Hind & Harrison Plush Co., Clark Mills, N. Y.

Manly, Charles M., Vice-Pres. and Ch. Engr., Manly Drive Co., New York

Maxim, Hiram P., Pres., The Maxim Silencer Co., Hartford, Conn.

Means, Edward C., Mgr. Rwy. & Lighting and Pwr. Div., Westinghouse Elec. & Mfg. Co., Denver, Colo.

Rupert, Judson W., Mgr., Virginia Haloid Co., New York

Stephenson, George F., Mgr. and Partner, Earl P. Cooper Co., Wis. Engines. Los Angeles, Cal.

Wood, Horatio N., 1st Lieut. of Engrs., U. S. Coast Guard, U. S. Cutter "Apache," Baltimore, Md.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bunge, L. W. A., Mech. Engr., Armour & Co., Chicago, Ill.

Cordes, Paul H., With Internatl. Steam Pump Co., Chicago, Ill.

Dowson, Harry R., Priv. Draftsman for F. W. Matthiessen, La Salle, Ill.

Greene, Harry T., Designing Engr., Aetna Explosives Co., New York

McCleary, Raymond M., Industrial Engr., Kirkman & Son, Brooklyn, N. Y.

Sticht, William, Engrg. Dept., The Singer Mfg. Co., Elizabethport, N. J.

Turner, Robert T., Jr.,
With Foreign Dept., Niles-Bement-Pond Co., New York

Wood, Roland T., in charge of Efficiency Dept., The Standard Tool Co., Cleveland, O.

Zeller, James H., Prod. Engr., American Bronze Co., Berwyn, Pa.

FOR CONSIDERATION AS JUNIOR

Adams, Porter H., Preparing Pocket Book for Aeronautical Engrs., Engineers' Club, Boston, Mass.

Bacon, Howard E., Mech. Engr., Rochester Rwy. & Lt. Co., Rochester, N. Y.

Batten, Loring W., Jr., Instr., Stevens Inst. of Tech., Hoboken, N. J.

Bodine, Alfred V., Mech. Engr., Winchester Repeating Arms Co., New Haven, Conn.

Campbell, Clifford C., Designer Spcl. Mchy., Victor Talking Mch. Co., Camden, N. J.

Clark, John W., Asst. Estimating Dept., McIntosh & Seymour, Auburn, N. Y.

Cooke, Stanley S., Student of Production, Remington Arms Union Metallic Cartridge Co., Bridgeport, Conn.

Dilcher, Harry J., Engr. of Tests, Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa.

Fuhr, Harry E., Student Apprentice, H. W. Johns-Manville Co., Manville, N. J.

Hilbert, Otto W., Student, Mass. Inst. of Tech., Boston, Mass.

Lang, Sidney H., Ch. Insptr., Wheelock, Lovejoy & Co., Cambridge, Mass.

McCune, Joseph C., Mech. Expert, Westinghouse Brake Cos., New York.

Magee, Christopher, Correspondent, Standard Underground Cable Co., Pittsburgh, Pa.

Masferrer, Joaquin R., Stationary Engr., Guanica Centrale, Ensenada, P. R.

Mellen, William H., Heat Treatment of Steel, Springfield, Mass.

Merkt, Theodore B. J., Exper. Engr., Pyrene Mfg. Co., New York

Nordenholt, George F., with Lewiston Bleachery & Dye Wks., Lewiston, Me.

Reed, Edwin W., Efficiency Engr., Reed & Prince Mfg. Co., Worcester, Mass.

Ryder, Earl R., Machinist, Goodman Mfg. Co., Chicago, Ill.

Savage, Leon L., Specl. App., Penn. Lines West of Pittsburgh, Columbus, O.

Severns, William H., Asst. Mech. Engrg. Lab., Purdue Univ., Lafayette, Ind.

Thurston, Arthur L., Inst. in Mech. Engrg., Worcester Poly. Inst., Worcester, Mass.

Walbridge, Arthur H., with Lens Dept., Bausch & Lomb Optical Co., Rochester, N. Y.

Wright, Douglas B., Steam and Chem. Testing Dept., Philadelphia Elec. Co., Philadelphia, Pa.

Young, Joseph E., U. S. Asst. Agri. Engr., Off. of Pub. Roads & Rural Engrg., U. S. Dept. of Agri., Washington, D. C.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

Price, William T., Mgr. and Ch. Engr., Pwr. Dept., De La Vergne Mch. Co., New York

PROMOTION FROM JUNIOR

Andrix, Earl R., Asst. Supt. of Pwr., Columbus Rwy. Pwr. & Lt. Co., Columbus, O.

Appleton, Henry W., 243 Van Houten Ave., Passaic, N. J.

Benner, Henry L., Secy. and Treas., Amer. Insulating Mchy. Co., Philadelphia, Pa.

Davey, Warren, Ch. Engr., Colgate & Co., Jersey City, N. J.

Dent, John A., Assoc. in Mech. Engrg., Univ. of Ill., Urbana, Ill.

Haglund, Gustav, Designer, Public Service Elec. Co., Newark, N. J.

Johnson, Harry D., Jr., Ch. Plant Engr., Studebaker Corp., So. Bend, Ind.

Lewis, Arthur S., Eastern Rep. and Trav. Mech. Engr., Chicago-Cleveland Car Roofing Co., New York

Loudon, Andrew C., Mech. Dept., Editor, Rwy. Age Gazette, New York

Peel, Fred P., Pres., Southern Sales Co., Washington, D. C.

Phelps, Charles C., Publicity Dept., Ingersoll-Rand Co., New York

Treat, Sidney W., Off. Mgr., The Schickel Motor Co., Stamford, Conn.

Van Deinse, A. F., Genl. Mgr., Springfield Gas & Elec. Co., Springfield, Mo.

Yates, Richard L., With Platt Iron Wks., Dayton, Ohio

SUMMARY

| | |
|---|---|
| New applications | 51 |
| Applications for change of grading: | |
| Promotion from Associate-Member | 1 |
| Promotion form Junior | 14 |
| Total | 66 |

# MOTION STUDY FOR THE CRIPPLED SOLDIER

BY FRANK B. GILBRETH, PROVIDENCE, R. I.,

Member of the Society

TO-DAY there are two million men living in Europe who have suffered the loss of limbs, faculties, or both, as a result of injuries in the great war. Before this war is over this number will be enormously increased. No one who has not actually seen hundreds of wounded soldiers writhing in agony in the cars or hospitals can fully realize the conditions that exist, but the pictures and accounts from the front have been so vivid that the whole world has been aroused to a concrete expression of sympathy and efforts to alleviate the immediate suffering.

However, there has been, as yet, little or no thought given to the permanent suffering that is by far the most serious aspect of the subject. What is to be done with these millions of cripples, when their injuries have been remedied as far as possible, and when they are obliged to become again a part of the working community? At the close of the war the various countries now engaged in it will find themselves for years, and probably decades, fully occupied in devising ways and means for paying the interest on their enormous debts. They will not be able to pension adequately and properly to provide financially for their astounding numbers of incapacitated soldiers. Neither would any system of pensioning, if that were financially possible, completely solve the problem, since the large majority of such cripples will be helped more by being provided with interest and occupation as well as financial support. The great problem that faces the world to-day is, therefore, immediate and permanent provision for enabling these millions of crippled soldiers to become self-supporting. This is a world problem rather than a problem for those countries only that are directly involved in the war, and demands a world-wide solution.

*Mr. Gilbreth has spent considerable time in Europe systematizing industrial plants and has been deeply impressed by the vast numbers of wounded and crippled soldiers who will find it difficult to obtain employment after the war. He proposes motion studies of various lines of industrial work, and similar investigations of the maimed soldiers, to determine what lines of work are open to the various types of cripples, as a means for providing employment and occupation for these unfortunate men.*

The crippled soldiers are of many types, for this war is a war of all classes, and not of the professional soldiers only, as one is at times inclined to think. In all countries, men from the colleges, the professions, the shops and the factories are at the front along with the usual military force. The cripples, therefore, will be of all types, and vary in training and capability as well as in the injuries that they receive. We might, therefore, roughly classify them as follows:

*a* Men who have done chiefly mental work.

*b* Men who have done chiefly physical work, but whose capabilities will allow them to be transferred to mental work.

*c* Men who have done physical work, and whose capabilities and inclinations are confined to physical work.

The first two classes can be handled with comparative ease when crippled. The third class presents the most difficult phase of the problem. This problem might be summarized as that of teaching and fitting cripples for some sort of productive work, and specially modifying and adapting the work to the individual capabilities, preferences, difficulties and shortcomings. The problem is an exaggerated new form of vocational guidance, vocational training, and systematic placement of men.

The educators have been quick to see their responsibilities in this work. They have provided, wherever possible, in existing or new institutions, opportunities for crippled brain workers to become productive, and have been ready and willing to devise opportunities and to furnish teaching for those previously engaged in physical work to learn and to use any mental work of which they are capable. They have, however, realized with equal rapidity their limitations in placing crippled soldiers whose bent is towards some type of physical work, as they have seen that this line of placement lies in the specialized field of the management engineer.

The engineer, both because of his training and practice, thinks largely in terms of physical capacity and its concrete results. The engineer of to-day emphasizes the human element as a factor in accomplishing results, and it is his peculiar province to make this human element most efficient. Knowing that the author had specialized for years in this type of work, educators in the various warring countries have urged him to attack this particular branch of the crippled soldiers' problem, and to put the results of modern management in general, and of motion study in particular, at the disposal of those in active charge of training the cripples. No great amount of urging was needed. The author has, since the war began, crossed more than a dozen European frontiers. He has visited many hospitals and recovery homes, and seen at first hand the frightful need, and he returns to this country not only with the desire to be of service, but with a definite plan as to how service can be most adequately rendered.

The method of attack of the problem is as follows: It is realized that the psychological feature is an important one. A prime necessity is to inspire the cripple with the feeling that he can remain, or become, a productive member of the community. This is done by gathering data as to cripples of various types who have succeeded in becoming useful and earning members of the community. These data consist of

Presented at a meeting of the New York local section of The American Society of Mechanical Engineers, October 12, 1915.

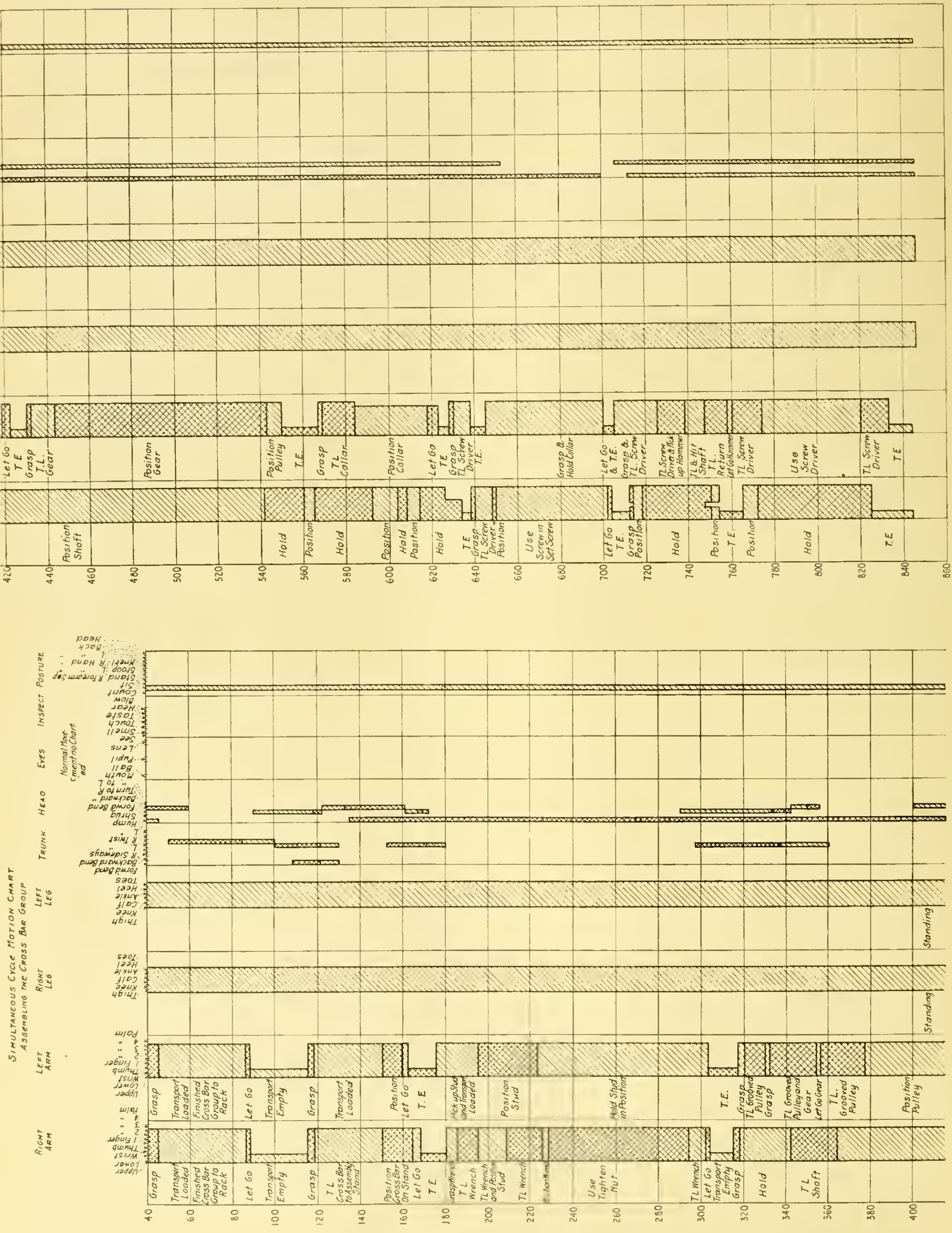


FIG. 1 CHART UTILIZED FOR VISUALIZING MOTIONS USED OR NECESSARY

concrete examples of men, women, or children incapacitated in any way, who have been enabled by any possible means to be useful to themselves and to society. Such data have been and are being accumulated at an astonishing rate. They serve not only to encourage the cripple by suggesting that what has been done, can be done, but also by indicating immediate methods of attack upon individual problems. Back of all these individual illustrations, however, must lie a scientific method for attacking the general and the individual condition of each cripple, for diagnosing the particular case, and prescribing an adequate remedy. This is our contribution towards the solution of the problem.

The motion study method of attack considers the work to be done as a *demand* for certain motions, and the proposed worker as a *supply* of certain motions. It aims

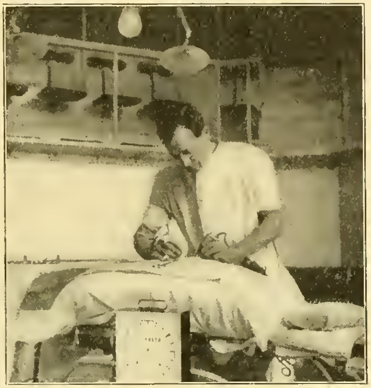

FIG. 2 ATTACHMENT OF ELECTRIC BULBS TO HANDS OF SURGEON FOR MAKING CHRONOCYCLEGRAPH OF SURGICAL OPERATION

*a* To consider all work from the motion study standpoint,—to discover exactly,

1 What motions *have* been used for the work.

2 What motions *may* be used for the work.

3 What motions *must* be used for the work.

*b* To discover what motions are possible to the proposed worker.

*c* To determine which type of work may best be adapted to the worker, and how.

It may be well to state that motion study considers always three groups of variables, which, in the industries, are

*a* The variables of the worker.

*b* The variables of the surroundings, equipment and tools.

*c* The variables of the motions.

In adapting motion study to the crippled soldiers' problem, we are considering these same three groups.

We realize that our problem is twofold in its aspect. It consists of

*a* Determining the type of work that the particular worker can best do.

*b* Determining that method by which he can best be taught to do the work.

The teaching element is more important in this new phase of adequate placement than it has ever been before, because in case a new or changed worker must be made useful, self-supporting and interested. That he become and remain interested implies the highest form of teaching and of learning.

The first step in adequate placement through motion study lies in visualizing the motions used, or necessary, in any given type of work. The simultaneous cycle motion chart is a device for recording and showing the interrelation of the individual motions and cycles of motions used in any method of performing any piece of work. This motion chart was devised and is used by us in our consulting work of motion study in the industries. Here we deal mostly with those who have the use of all their limbs and faculties, but the chart is equally applicable when dealing with cripples.

The elements of a cycle of decisions and motions, either running partly or wholly concurrently with other elements in the same or other cycles, consist of the following, arranged in varying sequences: 1. Search, 2. Find, 3. Select, 4. Grasp, 5. Position, 6. Assemble, 7. Use, 8. Dissemble, or

FIG. 3 CHRONOCYCLEGRAPH OF A COMPOSITOR PUTTING TYPE IN A STICK

take apart, 9. Inspect, 10. Transport, loaded, 11. Pre-position for next operation, 12. Release load, 13. Transport, empty, 14. Wait (unavoidable delay), 15. Wait (avoidable delay), 16. Rest (for overcoming fatigue).

The simultaneous cycle motion chart is best made on decimal cross-sectioned paper. The horizontal lines, reading from the top down, represent time. We have found that the thousandth of a minute is the best unit with which to work. The various vertical spaces are divided into anatomical groups, such as right arm and left arm, consisting of the subgroups, upper arm, lower arm, wrist, thumb, first finger, second finger, third, fourth, and palm; right leg and left leg, with the subgroups of thigh, knee, calf, ankle, heel and toes; trunk, with the subgroups of forward bend, backward bend, bend to right, bend to left, twist to right, twist to left, hump, and shrug; head, with the subgroups of forward bend, backward bend, turn to the right, turn to the left, and mouth; eyes, with the subgroups of ball, pupil and lens. There should also be the general heading of *inspection*, with the subdivisions of see, smell, touch, taste, hear, blow, and count; and the heading *posture* with the subdivisions of sit, stand, kneel, stoop, right forearm supported, left forearm supported, right hand supported, left hand supported, back supported and head supported, etc.

Charting the data in this manner makes it possible at a

glance to visualize a simultaneous cycle and the elements of the cycle of work done. The various motion cycles in the method under investigation are analyzed into these elements. Through this analysis we are able to work out new sequences, cycles and methods of doing any type of work. Thus many types of work that have been formerly considered possible only for the man in complete possession of all his members and faculties can be adapted to the maimed or crippled worker. The chart shows in a concrete form which members and faculties of the associated units or working members of the human body are doing the work, are inefficiently occupied, or are available for doing parts or all of the work. They enable us to see at a glance not only how motions are at the present being made, but the possibilities of shifting these motions to other members of the worker's body. In other words, when using these charts for the crippled soldiers' work we are enabled to proceed immediately and directly to the more efficient rearrangement, distribution and assignment of the necessary motions to the different remaining members.

Fig. 4 Chronocyclegraph of the Two Hands of a Girl Folding Handkerchiefs

The data included in these charts are gathered through various methods of making motion studies, especially by the use of the micromotion method and the chronocyclegraph method of recording motion in the research laboratory. Here records of methods are made with the special devices, microchronometer and the cinematograph, and also with the chronocyclegraph apparatus. The former type of records record the activity of the worker, the surroundings, equipment and tools, and also the time of the motions used. The latter records show the directions, speeds and paths of the motions. The records serve not only as data for the simultaneous cycle motion chart, but also as the most efficient of teaching devices. From the chronocyclegraph records are made motion models that not only make it possible for teacher and learner to visualize the desired motions from all viewpoints, but that also serve as path guides in case the worker taught is of the motor type.

Until recently, it has been considered good enough practice in the industries to teach the traditional or existing method of a successful workman. Through the methods and measuring devices of precision used in the motion study laboratory we are now able to record with exactness and in detail the methods of the most skilled workmen. By the use of the scientific method of analysis, measurement and synthesis we arrive at the method of least waste for performing the work. Through special teaching devices we then transfer the selected elements of skill and experience, in a new synthesized cycle of least waste, to workers who have never had that all around, non-guided experience or its slowly acquired skill. Not only are the methods transferred more efficiently but there is saving of time and effort to both teacher and learner, as is satisfactorily shown by learning curves of many past performances on widely varied types of work. The teaching devices, which we have specially adapted to appeal to as many types of workers as possible and to all available senses, are especially useful with crippled learners, where it is often necessary to specialize on some particular sense training.

The fatigue study that accompanies the motion study provides for the elimination of all unnecessary fatigue, and for adequate rest for overcoming necessary fatigue. Such study is imperative in the work with cripples, since the greatest of care must be taken that the maimed worker is not overtaxed.[1]

While this method of attack is bringing gratifying results, no great headway can be made with the crippled soldiers'

Fig. 5 Diagram of the Motions of a Girl Folding Handkerchiefs and a Wire Model Made from it

problem without worldwide coöperation. Such coöperation has been forthcoming wherever interest in the subject has been aroused. We gratefully acknowledge the receipt of suggestions and coöperation from members of our organization, from friends in many parts of America and other countries, and particularly from the alumni and friends of our Summer School of Scientific Management, and we most earnestly beg for more and more. We need photographs, records and histories of cases where cripples have been made comfortable and less fatigued in their work, and have been taught and are successfully doing work in spite of their apparently insurmountable handicaps. The crippling is of every conceivable type, and every success will encourage some disheartened invalid to take up life with a new courage. We want also suggestions for adaptations of machines, tools, and other equipment or surroundings to workers. For example, we have found that typewriter manufacturers have made attachments for the use of operators having one hand only. We have seen such an operator handle the modified machine with satisfactory results. We have found that slight modification of other machines permits assigning their operating and controlling parts to the remaining limbs of the workers, and thus makes possible their successful handling by injured operators. Any kind of an adjustment

[1] See "Fatigue Study," Sturgis and Walton.

or adaptation may be not only useful in its particular field, but may also form a missing link in an invention in an entirely different field. We will gladly take all data sent us and make them immediately useful to those working on the training of the injured soldiers in all countries. We have found it most efficient to think of all activity in terms of motions and decisions. Through more than thirty years of work in motion study we have facilities that make it possible to analyze all data into terms of motion economy, and thus to make them useful with the least waste in transmission or handling time.

This work of helping the crippled soldiers by teaching them to make the most of their motion possibilities should be the special contribution of the engineer in the field of social betterment. The opportunities for such work to-day are especially large because of the great war, but the methods that we now advise and use because of the great pressure will be available at all times. Through the reclamation service, if we may so call it, that we are using for the war cripples to-day, we are introducing a method that will never become unavailable or unnecessary.

We beg every member of the American Society of Mechanical Engineers to coöperate in this work, with us and with our friends abroad, who are waiting to pass on the data to those who need it so sorely. It is a work that is both timely and permanent. The need is sudden and new, but the data will be useful forever.

## DISCUSSION

L. M. Wallace (written): It is indeed gratifying that such an able investigator as Mr. Gilbreth has consented to devote time and effort toward solving the problem of providing for the instruction of those disabled by the European war. That large numbers of young men of the highest type are being crippled for life is indeed as distressing as that so many are losing their lives in this great world calamity. It is my conviction that it is just as noble an undertaking to attempt to provide suitable means of preparing the disabled for useful vocations as it is to attempt to stop the terrible conflict or to provide means of first aid. Indeed, it is a greater thing than many realize, because it will mean untold benefit to thousands now deprived of those avenues of activity to which they have been accustomed. It will mean the fitting for useful vocations of thousands, who otherwise would be dependents upon society, which is always a greater burden to the one so afflicted than to those of society who bear the expense of such disability. I therefore hope Mr. Gilbreth and his associates may achieve much and that the members of this Society will rally to his support by extending encouragement, helpful suggestions and material assistance in the form of thought, labor, and money, if desired.

Edward Van Winkle: There is no question but what the adoption of a machine to a crippled soldier or a man without arms or legs is the duty of the mechanical engineer. I remember seeing the driver of a speed car, a man without arms, travel over a hundred miles an hour in a machine especially designed for him. The steering gear of the machine was adapted with shoulder yokes and the rest of the apparatus was operated by his feet. I saw him go from high speed forward to high speed backward inside of 50 ft., and he had a record of 108 miles an hour. There is no doubt that there are a number of instances of that kind in which with special machines cripples have been enabled to emulate those with full faculties.

W. Herman Greul inquired whether Mr. Gilbreth had outlined any standard method of reporting these instances

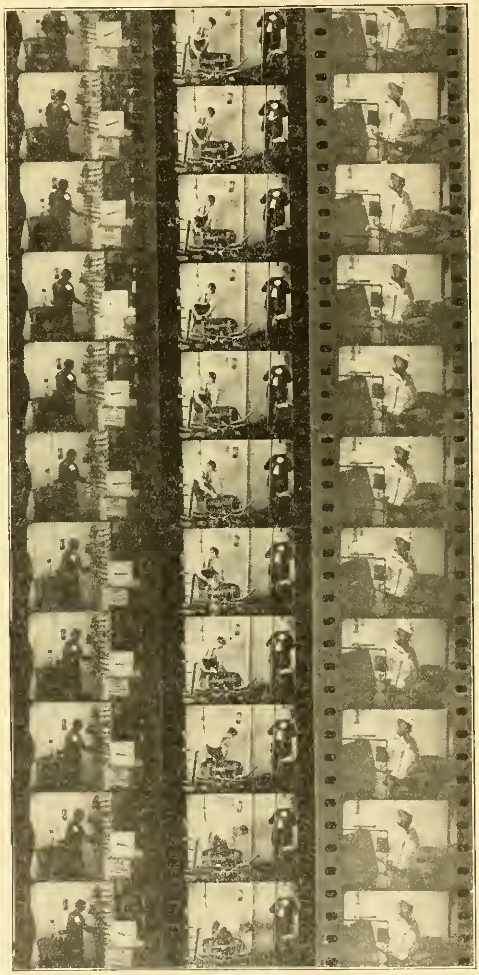

Fig. 6 Examples of Application of Cinematograph to Motion Studies of Workmen

which he could use in his tabulations. He wondered whether he had already tabulated the information which he desired, which would be very helpful in aiding the members to contribute.

Dr. Yeager, in his discussion, said, as a physician, he had been interested in cripples for a good many years, and in the course of his work he saw the necessity for providing

means of occupation for many of these cripples. Some three years ago he opened a school for the training of men who had been maimed or injured or who, through some disease, were incapacitated from active work. In this school as patients were men sixteen up to thirty-five, who were taught reed work of all kinds, reed furniture making, rush seating and basket making. To the men who have the use of one and one-half hands, and whose minds are sufficiently developed, mechanical drawing is taught. For the men with one hand only, we selected glass mosaic work; a plan was devised for holding the glass so that with the one hand the worker could take his glass cutter, cut the piece of glass and fit it into the pattern he was making. We have taught show card writing, and also silversmithing.

As you will notice, most of these trades are for men who have the use of two good hands. Reed work needs two good hands. An encouraging feature of this work is that men who had never done any of this kind of work before, men who had never done any skilled work with their hands at all, would, in the very shortest space of time, become expert. I remember one young man, a structural iron worker, had an injury in which he lost one leg. He had no other trade, but he came to the school and became an expert silversmith; he did very beautiful work. He developed into a very fine draftsman, although he had no home training. He was a man from the very lowest circles, but the surroundings, the beautiful designs that we gave him, developed in him a desire for creating beautiful things, and he became a very skilled craftsman.

Another case was that of a young man who was born with his hands in an abnormal position, rendering them practically useless. We taught him show card writing. He held his pencil in his left hand, and he was able to draw and make letters very well. Another young man, whose right hand was paralyzed, just had sufficient power to hold his paper and pen, to do mechanical drawing.

A man who had paralysis in both legs, and who needed two crutches, as both his legs dangled under him in a very unseemly fashion, learned the trade of chair caning, and during the summer vacation he managed to get the contract for a large club which needed several hundred chairs, and this cripple engaged ten able bodied men to work for him.

A boy with a very bad deformity of the hip needed two crutches to go about the workshop, but notwithstanding this he was able to work very well.

The work at this school is being done in the City of New York. It is the only school of its kind in the country, and whereas we have not attempted to get the men into work where machinery is required, we feel that we are filling a definite place in the work that we have done.

Mr. Hanau: When radium was discovered it was thought to be good for anything, for everything, for tuberculosis, for cancer, and for almost everything. The same remark applies to moving pictures. If you consider the moving picture, however, you must always keep in mind that it is a perspective. In the second place, you must keep in mind that the movements are not all in plane, so that they are very deceiving. To represent the three dimensions by photographs, you have to take them from the three sides, that is, the front, side and back projections. Then you can combine a movement which will be followed up very accurately. While this method is very good for efficiency, I do not think it is of very much value for just the purpose of this paper.

In working out data for members and other parts of the body for crippled soldiers, or maimed persons, one must be very careful. Such data cannot be represented only by a perspective picture, although perspective pictures are very valuable in shop practice.

F. Zur Nedden: A few weeks ago Mr. Gilbreth showed me a novel improvement of his method, giving the means for taking motion studies in the tri-dimensional way. For this purpose, Mr. Gilbreth first photographs a tri-dimensional net of white lights, he then removes the net, places the workman in position, and makes motion studies. By this

Fig. 7 Cyclegraph of a Man Operating a Machine with Which He is Not Familiar

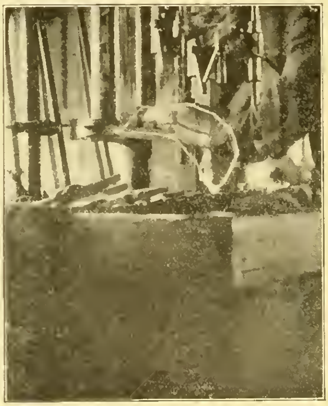

Fig. 8 Characteristic Orbit of the Same Man After Making a Half Dozen Pieces on the Machine

Fig. 9 Cyclegraph of Same Machine After Improvements Made to Facilitate Handling of Material

way he can conceive, especially if he makes photographs stereoptically, exactly the place every motion in space occurs. This would meet the objection raised by Mr. Hanau.

H. E. Resseler gave an instance of a mechanical device made recently in one of our hospitals in New York City. A young girl had a form of tetanus and by removing the muscles of the lower jawbone, and making a device with a spring, to be wound up just like one would wind up a clock, fastening it to the jaw and running it over the head, the jaw was kept in constant motion. After about three weeks the device was taken off. It was surprising to note how the muscles of the inferior maxillary had developed. The girl was then put to chewing gum, and the development of the muscles of the lower jawbone was continued.

James Gibbons: The work proposed to be carried out in Europe with a view to aiding crippled soldiers should hold a very important lesson for us in this country, because it seems it is an attempt to approach the efficiency question from another point of view than that which we are accustomed to. There is a tendency I think on the part of the efficiency engineer to pay more attention to the man of efficiency and to a certain extent discard the less efficient man, and a good deal of the opposition to efficiency methods which no doubt exists in the minds of many, and especially of workmen, is due to the feeling that the men naturally less efficient will be sacrificed to a great extent to those more efficient.

The fortunes of Europe are forcing upon men the necessity of taking care of their less efficient fellows.

From the point of view of the working public and from the point of the good of the country as a whole, this is perhaps the real foundation on which we should build on efficiency efforts—from the bottom up rather than from the top down; and I think we would be making a great mistake if with our own prosperity and our own good fortune in this country we should not give our careful attention to what is being done in Europe and watch carefully for the results which will come from this effort to raise the efficiency of those who are naturally inefficient.

W. N. Polakov: The paper by Mr. Gilbreth is of great importance, not only for the European problem of the near future, but for that in the United States, which is, so to speak, permanent, because industrial accidents happen and will happen in this country, although probably in diminishing proportion. It is well known to us how much money is being paid to the crippled soldiers of former wars, although if provision of some kind had been made in this country they could have been put to productive work and not be a burden on the country, but be productive members of society; but aside from that there was a question raised here whether it is in the domain of an engineer to look into this matter. In my opinion, it is most emphatically so, and I think we all owe Mr. Gilbreth thanks that he raised this question in our own Society.

The case of the crippled soldier is nothing but using the triple expansion human body as a compound, or something less than that, as it were, and therefore it is a problem of engineering, and of the works manager to adapt these conditions, or the men to the conditions, so that they will be useful. It is not so much the question of the selection of the man for the particular work, as the adaptation of the available man to the work which is to be done, whether the man is crippled or not.

As to the instruments devised by Mr. Gilbreth, I have watched and studied them in actual use, in the New England Butt Co.'s laboratory, although the details were too complicated to be explained in a short talk. The point of importance is that the motion shall be studied in order to save the waste motions and find out in what industrial processes certain limbs and certain parts of the body, certain muscles, are used.

In a factory where wearing apparel is sewn, the legs are absolutely unnecessary, as the machines are driven by a motor. In many other industries, when we consider it necessary to employ able-bodied men, we are doing a great injustice to those who are crippled, and more than that, we manifest our own lack of understanding. We do not want legs for the man who is working with his brains, and vice versa for the messenger boy it is not necessary for him to have two hands. For a telegraph operator two arms or two hands are entirely unnecessary, and many other examples could be cited.

Alwin Louis Schaller: I think that one of the points ought to be emphasized that Mr. Gilbreth brought out in his paper, and that is the psychic state in which the man must be brought before he can be made successful. The only reason why a cripple is so successful is because he has a will and a determination to devise his own methods for doing things.

I believe that one of the largest problems that Mr. Gilbreth had to confront when he began to reclaim these crippled soldiers was to get them into a state of mind where they could forget the discouragements into which they had probably fallen after receiving their wounds and realizing that they would have to go through life in a crippled condition.

Robert Thurston Kent, who presented the paper, said: Last August I spent a day at Mr. Gilbreth's laboratory and saw what he had developed in the four years since I was associated with him, and Mr. Gilbreth converted me to a number of things that I believed were absolutely impossible two or three years ago, and I would suggest that all who are skeptical as to the value of the moving pictures of stereoscopic photographs and the three dimensions visit Mr. Gilbreth's laboratory, where they will learn a great deal.

The problem of efficiency or scientific management is to point out the job at which a man is a first-class man and put him in it.

Mr. Gilbreth has a standard method of tabulating. He lays out a chart divided into different groups, as explained in his paper—the head group, the different arm groups, etc., subdividing them into the forearm, the hand, thumb, and so on. By means of his photographs he finds out the relevant amount of time each member of the body is employed on a given job; he plots them on a vertical scale as to time. Striking a curve through these ordinates, he can see the relative importance of each particular member of the body in doing certain work.

The particular method employed is to take these charts and see if these motions of all the parts cannot be eliminated altogether, so that in the case of only a right hand motion, the motion of the left hand is gotten rid of, making it all a job on which the right hand only is employed.

# GAS VOLUME AND DUST CONCENTRATION DETERMINATION IN CONNECTION WITH THE COTTRELL PROCESS

WM. N. DREW, LOS ANGELES, CAL.

Member of the Society

It is evident that, for general engineering work, any apparatus for determining the velocity of the gases in the conduits of a plant to which a Cottrell treater is to be applied must be portable, accurate, simple in construction, and easily and readily manipulated. Anemometers are unreliable in a fluctuating flow, otherwise they comply with all the above requirements; they are necessarily somewhat delicate, and in hot, dusty gases their mechanism may be seriously deranged. Venturi tubes are easily manipulated and very accurate, but are not portable. The Thomas electric meter is extremely accurate, but it also is not portable.

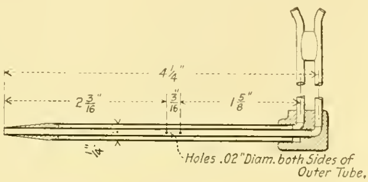


Fig. 1 Type of Pitot Tube Used

The Pitot tube is the last choice and fulfills very completely all the stated requirements, while in addition it is inexpensive and easily constructed. This instrument is a well-known one, and tests of particular types have been the subject of extensive investigations. It is estimated that, with the type of Pitot tube illustrated in Fig. 1, which is the standard testing tube of the American Blower Company, and with accurate gages, it is possible to obtain an accuracy of within 1 per cent. However, even with an absolutely accurate tube, uncontrollable conditions in the gas flow may vary results a like amount.

The Pitot tube follows the law of falling bodies, and a working formula based on this may be derived as follows:

where

- $T$ = absolute temperature of flowing gas in deg. fahr.
- $K$ = absolute temperature of flowing gas in deg. cent.
- $P$ = absolute pressure of flowing gas in lb. per sq. in.
- $B$ = absolute pressure of flowing gas in inches of mercury
- $d$ = weight per cu. ft. of flowing gas at a given temperature and pressure
- $G$ = specific gravity of flowing gas (air = 1.0)
- $V$ = actual velocity of flowing gas in ft. per sec.
- $h_f$ = height in ft. of a homogeneous column of gas at given temperature and pressure producing V
- $h$ = corresponding height of water column in in.
- $d_w$ = weight per cu. ft. of water = 62.37 lb. at 60 deg. fahr.
- $d_a$ = weight per cu. ft. of air at 32 deg. fahr. and 14.7 lb. = 0.08073 lb.
- $g$ = acceleration due to gravity, taken as 32.16

$$V=\sqrt{h_f}$$

$$=\sqrt{\frac{2ghd_w}{12d}}$$

since $dh_f=\frac{hd_w}{12}$ and $d=d_aG\frac{P}{14.7}\times\frac{491.2}{T}$

hence

$$V=11.12\sqrt{\frac{hT}{PG}} \qquad (1)$$

$$=15.88\sqrt{\frac{hT}{BG}} \qquad (2)$$

$$=21.30\sqrt{\frac{hK}{BG}} \qquad (3)$$

For air $G=1$ and at atmospheric pressure $B=29.92$, so (3) becomes

$$V=3.894\sqrt{hK} \qquad (4)$$

Within the errors of observation, these formulae are accurate for dry air up to 100 ft. per sec., but at 183 ft. per sec. they give results 6 per cent too high and at 383 ft. per sec. 15 per cent too high.

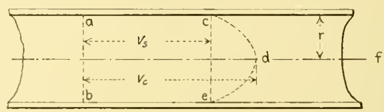


Fig. 2 Parabolic Form of Curve Expressing the Velocity in Cross-section of Conduit

The location of the Pitot tube in the conduit is a matter of considerable importance, especially as it is usually desired to obtain the average velocity for a given cross section. The law governing the variation of velocity from center to side of a conduit has not been definitely established, and, moreover, the determination of the velocity contour is difficult owing to errors of observation, abnormalities of flow and to the impossibility of making a measurement at the extreme edge of the pipe.

If we assume that the curve expressing the velocity at a cross section is a parabola with its vertex at the axis of the pipe, we may deduce a relation between the center velocity $V_c$ and the mean velocity $V_m$ in a cylindrical conduit of circular cross section as shown in Fig. 2. From this diagram it may be seen that the amount of fluid passing the section each second is represented by the solid generated by rotating the figure *acdeb* about *fd* as an axis. The volume of this may be divided into two parts, one a cylinder *aceb* and the other a paraboloid *cde*. The volume of the cylinder is $\pi r^2 V_s$ and of the paraboloid $\frac{1}{2}\pi r^2 (V_c - V_s)$. If we divide the total volume of the solid by the area of the pipe we obtain $V_m = \frac{2\pi r^2 V_s + \pi r^2 (V_c - V_s)}{2\pi r^2} = \frac{V_s + V_c}{2}$

If we assume that the surface velocity is one half that at the center, we may write $V_m = 0.75\ V_c$.

Similarly on the assumption that the contour is repre-

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sented by an ellipse, since the volume of an ellipsoid is two-thirds that of the circumscribed cylinder, we may write

$$V_m = 3\pi r^2 V_s + 2\pi r^2 \; \frac{(V_c - V_s)}{3\pi r^2} \quad \text{and on}$$

assumption that $V_c = 2V_s$, $V_m = 0.83\ V_c$

Although it is apparent that an approximate relation exists between the mean and maximum velocities in a conduit of circular section, too much dependence must not be placed on this ratio. Loeb (Journal A. S. Nav. Eng., vol. 24, p. 1115, 1912) states that a single Pitot tube at the center of a circular duct will have a coefficient of mean velocity of 0.91 to 0.94, depending on the size of the duct and the velocity of the air. For a 12 in. galvanized iron pipe, Rowse found that results within 2 per cent may be obtained by using the ratio 0.895.

This regular flow is disturbed by expansion, contraction, or curvature of the conduit, and more especially by obstructions in the particular cross section selected. In a circular duct, the cross section may be divided into a number of annular rings each having the same area, and then, by taking readings at equal intervals around these rings, velocity readings can be obtained and readily averaged. In averaging these readings, the mean of their square roots must be used rather than their direct arithmetical mean.

Traverses in a pipe along one diameter only are not sufficient, as readings on vertical and horizontal diameters are rarely the same, except at the points nearest the center. For a conduit of any section, a more accurate method is to make these traverses along several diameters, and then, after making a contour for each diameter, combine these into one which will show the contour for the entire cross section. Fig. 3 shows a contour obtained in this way. Twelve readings were made on each of the four diameters by a movable Pitot tube, another Pitot tube being kept fixed in position

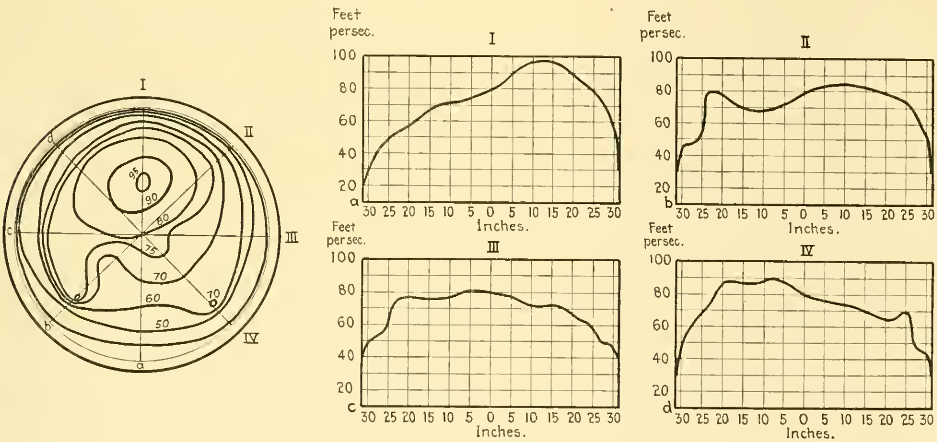


Fig. 3 Results from Traverse Readings with Movable Pitot Tube across Different Diameters of Conduit

tions. It is probable that in a gas stream, as in a water stream, the static pressure after expansion or contraction will be higher than the normal, and that after a curve the indications of pressure on the concave side will be high and on the convex side low. Rowse found that gas flowed through a pipe with a wave or spiral motion even when many screens were inserted to straighten out the stream lines. Curves obtained by traversing the cross section of pipes with the Pitot tube show more or less uniformity.

Rowse states that in gas measurements a Pitot tube station should be preceded by a length of pipe 20 to 38 times the pipe diameter. Fan discharge into a pipe line disturbs the flow somewhat, but Treat (Trans. A.S.M.E., vol. 34, p. 1019, 1912) states that good Pitot tube measurements can be taken 8 to 12 diameters away from the fan.

Since there are so many unknown conditions in a conduit conveying gases, it is evident that the most reliable results will be obtained by making a large number of measurements at the center of the cross section and readings being taken simultaneously with the movable tube. The velocity readings obtained with the fixed tube were averaged and this velocity used as a base from which to correct the velocities obtained with the movable tube, since all the velocities in the cross section are continually varying; it was assumed that the other velocities varied according to the ratio between the average center velocity and the "instantaneous" center velocity, and this ratio was applied as a correction. With a planimeter, the area shown on the final contour plot corresponding to each velocity was measured, and from this a weighted mean was calculated for the entire cross section. In this particular case the mean velocity was 64 ft. per sec.; and it is interesting to note that the region of maximum velocity was not at the center. The cross section shown is in a stack carrying gases from a cement kiln, and is 100 ft., or about 20 diameters, from the mouth of the kiln. In the stack base, the kiln gases are first deflected downwards by a

curtain wall, and on resuming their general upward travel their motion acquires a horizontal component in "reaching out" for the stack entrance, and the gas volume "hugs" the stack all the way to the cross-section shown.

After several such determinations as this, a ratio between the mean velocity and the velocity at any other point can be determined; and by using this ratio one measurement will indicate the total gas volume. In choosing such a point, it is obvious that the location should be such that no rapid

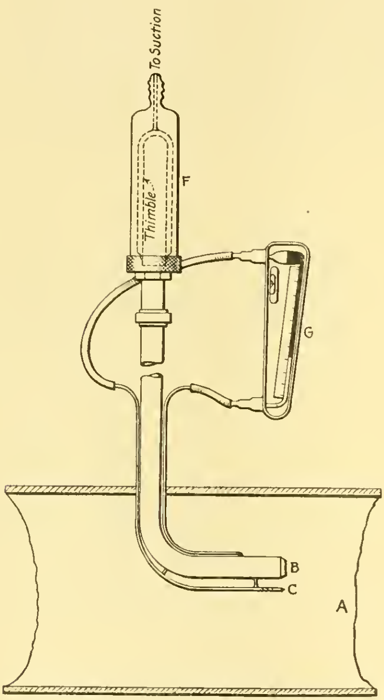


Fig. 4 Details of Apparatus Used for Entrapping Known Volume of Dust-laden Gas

changes in velocity are occurring. This point is near the region of highest velocity rather than at the point of average velocity.

## Dust Determination

After the gas volume to be delivered to the treater has been determined and the treater built and placed in commission, the question arises: How much of the suspended matter is the treater collecting? This is a natural question from the engineer's standpoint, for he always wants to know the efficiency of his apparatus, and also from the client's standpoint, for it behooves him to know whether or not any valuable material is being lost. Also, it may happen to be a natural question from the legal standpoint, for it might be necessary to know if any regulations regarding emission of fumes are being violated.

Aside from the question of the amount of the escaping material, it is desirable to know its composition, so that the percentage loss of valuable material may be calculated. In order that all these questions may be determined, it is necessary to remove some of the gas with its accompanying dust. The ideal way to do this would be to entrap a known volume of the dust-laden gas, weigh and analyze the solid matter carried by it, and from these data calculate the ratio desired.

Fig. 4 shows diagrammatically an apparatus which is used in an attempt to approximate this ideal method. *A* is a conduit through which the gases and dust are passing. In this conduit is placed a tube *B*, with its mouth pointing toward the flow of the gases, and, at the other end of this tube, suction is applied to draw through some of the gas with its accompanying dust.

As the gas passes through the pipe it reaches the filter *F*, which retains the solid matter but allows the gas to pass. This filter consists essentially of two parts, a Soxhlet fat extraction thimble, and a holder of brass hollowed to receive the thimble. The essential features of this holder are a tight fit at the mouth when the knurled nut is screwed home, and a good clearance, say about 1/8 in., around all sides of the thimble. The reason for this first essential is obvious, for leakage must be prevented, while the second one is indicated by experience, tests having shown that the filter quickly clogs if there is only a slight space between the thimble and the holder.

In order that a fair sample of the gas and dust may be obtained, the suction applied should be such that the velocity at the mouth of tube is the same as the velocity in the stack, for, if it is greater, more dust is drawn through in a given time than should be, and vice versa. To adjust the velocity in *B*, two static tubes are used, one of which, *C*, is a closed tube with small holes near its tip, the other is a tube drawn down to a small hole and opening to the inside surface of *B* near its mouth. The other ends of these tubes are connected to a balancing gauge, *G*, and the suction adjusted so that the column is always in balance.

After suction has been applied for a known length of time the filter is removed, dried, and weighed; then from the amount of dust in the filter, the time of aspiration, and the ratio of the area of *B* to the area of the conduit, the amount of dust passing through the conduit *A* in a unit of time is calculated.

An important feature of the operation of this and other apparatus using a filter is the proper previous and subsequent drying of the filter thimble. The amount of dust caught is usually so small that an appreciable error is introduced if moisture is present in the thimble. The thimble should be dried at about 100 deg. cent. for two hours before using, and at the same temperature and for the same length of time after filtration.

Another method often used, and it is accurate, although perhaps more difficult of manipulation, is to aspirate the gas through a meter and catch the dust on a filter as before, measuring the gas volume and weighing the dust. In this method the balancing tubes are dispensed with, but the temperature and pressure of the gas passing through the meter must be determined, and the temperature in the conduit must also be known in order to calculate the dust concentration correctly.

# THE MANUFACTURE OF LEATHER BELTING

BY F. H. SMALL,[1] WORCESTER, MASS.,

Non-Member

THE manufacture of leather belting has its beginnings on the farms of New England, the grazing ranges of the Argentine, the rocky Alpine pastures of Switzerland, the fertile plains of France—wherever cattle are raised. The cattle supply the hides which are one of the essential raw materials of the tanner and so of the belt maker. It is essential that the cattle industry should prosper if leather is to remain as universally usable a commodity as heretofore. Cattle are raised primarily for their labor value, their milk value and their meat value; the hide is very much of a by-product and the matter of production of a hide specially suited to the requirements of the tanner is but an infinitesimal incentive to the cattle grower. When steer hides sell at better than 26 cents a pound as they have this year, when as much as $40.00 per hide must be paid to secure a particular selection, it seems as though the hide, even if but a by-product, represents a sufficiently large percentage value to secure from the cattle grower an endeavor to produce a satisfactory hide. The tanner, however, has had a hard time to establish this point of view although, aided by governmental agencies whose interests have been different but objective similar, progress has been made.

The particular evils of which the tanner has complained and for which the cattle raiser is responsible are three: barbed wire, brands and grubs. Barbed wire fences lead to scratches on the hair or grain side of the hide, which though they later heal yet constitute imperfections; branding destroys the hide fibre and makes so much of the hide as is touched by the branding iron absolutely worthless for purposes of belting manufacture; grubs are worst of all, for the reason that they do their damage in the very best part of the hide and oftentimes are so numerous that a hide affected by them gives the appearance of having been used as a target for a shot gun.

The first two evils are subject to individual correction; the last can be remedied only by concerted and wide-spread action. It is a question for governmental investigation and legislation. The investigation has been and is going on, but the efficient remedy is not yet, though progress is making. In one district in Denmark, for instance, where they can be reasonably autocratic, by making the presence of warbled cattle in herd punishable by fine, they reduced in six years' time the percentage of warbled cattle from 18 to 1. The above is mentioned for two reasons: *first*, to bespeak your interest in any measures that may come to your attention, calculated to improve the conditions mentioned, and *second*, to show you how uncontrollably imperfect is one of the tanners' raw materials.

Apart from damages as cited there are material differences in hides—differences in texture, in plumpness, in uniformity, etc. It is generally true, for instance, that cattle in warm countries have thick hides and short hair, while in cold climates the reverse is true. Our supply of first quality, extra heavy hides comes almost wholly from southern Europe, and these being no longer obtainable as a consequence of the war we are hard put to it to produce extra heavy leather. Some cattle have hides which are very thick over the kidneys and thin over the shoulders; others show this difference much less markedly.

When the hide is removed, the way in which it is done is again a matter of keen interest to the tanner. Cuts in the hide made by the butcher when taking it off the animal lessen the value very materially. The *take-off* of hides from the large packing houses is usually excellent, the result of specific attention, carefully trained and expert labor. It is quite otherwise with the average country hides taken off by the town butcher, which despite the efforts of the Tanners Associations, are still a source of shame. The flaying is so bad that they rarely bring the price of a packer hide and they represent a real and needless economic waste. Abroad, methods of so-called mechanical flaying have been introduced to avoid butcher cuts. By these methods the hide is pulled and hammered from the carcass and such hides usually command a premium, 50 cents a hide being an average figure at the Paris auctions.

What happens to the hide after its removal from the animal and before the tanner gets it, is again of importance. Hide, being essentially gelatine, readily spoils and must be preserved against decomposition. Two methods of preserving or curing hides are in vogue, viz.: drying and salting. The first is ordinarily too uncertain to permit of the use of hides cured in this way for belting and practically all hides tanned for belting are what are known as green-salted hides.

If the belt manufacturer tans the leather which he makes into belting—and this is the ideal arrangement—he buys so far as possible green-salted hides, free from scratches, brands and grubs, short-haired, of as uniform thickness as obtainable and which have been skilfully taken off, so that they are free from butcher cuts; i. e., the manufacture of first quality belting begins with the purchase of first quality hides.

Before being used for belting these hides must be tanned, i. e., so treated that they will not decompose or spoil and will remain flexible. There are various methods of tanning hides but whatever the method used, the first steps, usually spoken of as the beam house treatment, are essentially the same, namely: preliminary washing with water to remove dirt and the salt or other material which may have been used to *cure* the hide; a cleaning of the flesh side to remove superfluous flesh, fat, etc., left on in the flaying—a soaking in milk of lime, or some other depilatory solution, to loosen the hair which is then pushed off by machine or with a dull two-handled knife; and a final washing to remove at least in part the unhairing chemical and to clean the hide. The quality of the finished leather depends in very large measure on the successful performance of these apparently simple operations. It is an old saying that leather is made in the beam house.

The conversion of the hide as above prepared into leather may be brought about through the use of any one of a variety of tanning materials, the peculiar characteristics of the finished leather being governed by the material used.

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[1] Chemist of The Graton & Knight Mfg. Co.

Presented at the meeting of the Providence Association of Mechanical Engineers, affiliated with THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, September 22, 1915.

Only a few of these materials will be mentioned and such only as have a special interest to the belt manufacturer. One of the simplest and oldest methods of tanning is to cover the raw hide in the moist condition with grease and then continually manipulate it as it dries, thus working the grease into the inmost fibres of the hide and producing a grease-tanned leather. Grease-tanned leather has little more fullness or body than the original hide, but it is exceptionally strong. The so-called mechanical lace used for lacing together belting is tanned in this way.

Another method of tanning which has come down to us from olden times is to work into the hide a mixture of alum and salt. This gives a somewhat fuller leather than grease and is used before the grease treatment by some tanners of mechanical lace because of the fullness gained, but it is at the expense of the toughness and wearing qualities of the lace.

A modern tannage of somewhat similar nature is that with salts of chromium, the hide being immersed in a solution of one of these salts. Chrome tanned leather is fuller than alum tanned and much more permanent. Water will seriously injure alum-tanned leather, causing it to revert nearly to the condition of raw hide and to become hard and cracky, whereas water has little or no effect on chrome leather. Chrome leather may even be immersed in boiling water for some little time without serious damage to the leather. Most of the so-called steam-proof belting is made from chrome-tanned leather.,

By far the greatest percentage of heavy leather, and in particular that used for belting, is tanned with a tannin derived from some vegetable material. The procedure of the tanning process as early practiced with vegetable materials was to spread the hides out flat in a vat with a relatively thick layer of the tanning material between the hides, the vat finally being filled with water. The water served as a medium of exchange, extracting the tannin from the vegetable material and giving it to the hide which absorbing it became tanned. The process was slow, often necessitating a year or two to effect the conversion of the hide into leather.

An improvement in the process was effected by substituting for the water a tan liquor obtained by leaching the tanning material in large tubs; i. e., extracting the soluble tannin by passing hot water through the ground raw material. Nowadays the use of the raw tanning material by the tanner is almost a thing of the past. He uses instead tanning extract prepared at plants usually located where the supply of raw material is abundant and which is a concentrated solution of tannin obtained by leaching the raw material with water as was formerly done at the tannery, and then evaporating away much of the water in a partial vacuum at low temperature and yielding as the commercial product ordinarily a thick brown liquid containing about 25 per cent actual tannin. Not merely does this supply the tanner with his tanning material in a form much more convenient for use, but it has the further decided advantage that the extract admits much more easily of analytical control and so makes possible the use of a determinate and uniform tanning agent. Since uniform product demands uniform raw material this is an improvement of no mean order.

Not so long ago—in fact as recently as 1890—practically all the vegetable tanned heavy leather in this country was made with either hemlock or oak bark, or a mixture of the two. Now, while the old names, hemlock, oak and union, are still retained, it would be hard to find a tanner making leather with these materials alone. The present-day tanner uses not merely hemlock and oak, but chestnut wood, or valonia, or myrobalans, or mimosa, or quebracho, or wattle, or mallet, or algarobilla, etc., some twenty-five or thirty materials being commercially available.

With an increased range of materials came, of necessity, a study of the leather-making qualities of each. Marked differences appeared. For instance, the tannin of valonia was found to decompose rather rapidly, forming and depositing insoluble ellagic acid. The English tanner, earlier to use these materials, had discovered this by experience, and by using valonia and insuring the deposition of the ellagic acid in his leather, was making the solid English sole, waterproof and long-wearing, which earned him a reputation the world over. A myrobalan liquor was found to sour very rapidly, yielding eight times as much acid, for instance, as mimosa under the same conditions.

The leather-forming value of the materials varied; valonia would produce over 100 lb. of finished leather as against 75 for myrobalans, from the same weight of hide. Chestnut wood produced a leather of tensile strength over 3,000 lb. to the sq. in., while oak bark under similar conditions gave one of less than two. Here certainly was knowledge and opportunity the tanner could not neglect. Knowing what qualities he desired in his finished product, he could, by a careful selection of tanning materials, go far toward securing these qualities, this material making for fullness, that for strength, etc. The progressive tanner, who wanted to make the best belting leather could not afford to make oak belting with oak bark alone, and he did not, and his leather is the better in consequence.

The objection to practically all the tannages, aside from that with vegetable tannin, is that they do not make a plump, full, solid leather. The leather produced by them is tough, but thin and open. The original hide constitutes much the largest percentage of the finished product, only a small quantity of the tanning material remaining in the leather. This is in marked contrast to the vegetable tannage in which so much tannin and other matters is deposited in and on the fibres of the hide that the original hide constitutes less than 50 per cent of the final leather.

Lack of firmness is a serious deficiency in a leather to be used for belting. Nevertheless, leathers made with some of the above materials have sufficiently valuable properties so that they have made considerable headway for belting even despite their failings. Chrome leather, for instance, can be produced in a comparatively short time. It will run practically unharmed in a temperature where vegetable tanned leather would revert to a brittle, formless mass. It can be made exceptionally flexible. It has a high coefficient of friction. Consequently belting from chrome leather has found a place for itself, which would be larger, were it not for the deficiencies resultant from the lightness of the tannage, the lack of solidity of the leather and the necessarily high cost because of the small leather-yield. A leather tanned with a combination of alum and gambier, the gambier being used to supply the deficiencies of the alum as a filling material, has likewise had some vogue. It is tough and pliable, and has given good service for high-speed work.

The latest development in the way of a new tannage is that originated and used by the Graton & Knight Mfg. Co.,

with which I am connected, in the production of its Spartan leather. Spartan leather is a full, reasonably firm and solid leather, resembling in this respect the vegetable-tanned leathers, though more flexible. It has a higher coefficient of friction than chrome and consequently a better pulley grip and it will be remembered chrome is superior to oak in this respect. It is more resistant to heat and harmful agencies in general than chrome or any other leather. We have used it successfully for overload conditions so severe that engineers have said success was impossible. As an illustration, the worker roll on a Vaughn setting-out machine is run by similar belts traveling over similar pulleys at the two ends of the roll; in a service test we were using a chrome belt at one end and a Spartan at the other, alike except as to tannage. One day the chrome belt accidentally came off and to even our astonishment the machine kept right at work with only the Spartan belt in service. As a matter of curiosity we then reversed the conditions, leaving on the chrome belt, but it slipped and the machine refused to work.

It was stated above, that if the belt maker knew what qualities he wanted in the leather from which he made his belting, he could go far toward obtaining these by proper choice and application of tanning material. To enumerate these qualities as our experience has shown them:

*First* We need good driving surface, sufficient friction between belt and pulley to eliminate slippage as completely as may be and to enable the belt to carry its load under minimum tension, thus avoiding useless waste of power at the bearings;

*Second* Lateral stiffness coupled with pliability, the stiffness to keep the belt from twisting and waving and to prevent its curling at the edges when shifted; the pliability to enable it to hug the pulley, wrapping itself round and so securing large arc of contact, and to enable it to alter its shape with the minimum of internal resistance as it travels round the pulley;

*Third* Good tensile strength that it may carry its load without breaking;

*Fourth* Little stretch but considerable elasticity; the former so that it will need to be shortened as seldom as may be, i. e., will do its work uninterruptedly; the latter so that it may easily take up and let go its load as it travels round the pulley;

*Fifth* Firmness or stability, much the same as lateral stiffness, so that the leather springs little when cut, holds its shape, remains straight and runs true on the pulleys;

*Sixth* Resistance to external conditions, such as heat, moisture, chemicals, etc.: that it may do its work in any place, at any time, and enduringly;

*Seventh* Low initial cost.

It is apparent that no leather can have all these qualities in the highest degree, for some of them are incompatible. Sole leather would do admirably as far as lateral stiffness, little stretch, and firmness are concerned, but would fail lamentably to satisfy the requirements of pliability, tensile strength, elasticity, etc. The best result we can achieve is bound to be somewhat of a compromise. We must aim to get the largest measure possible of the most desirable qualities in our leather, with the least necessary sacrifice of others. There is where the beltmaker who tans his own leather has a marked advantage in that he may bend all his efforts to so adjusting his tannage as to secure the best possible compromise. Quality belting demands then,—first, suitable hides,—second, suitable tannage.

We now have the leather and may proceed to prepare it for making into belting. Of the hides which we have tanned only 50 per cent may legitimately be cut up into belting and less than 40 per cent will go into first quality belting. First, we reject the bellies, cropping or cutting them off at the flank; this loses us 25 per cent of the hide. Next we cut off the shoulder at a point 4 ft. 4 in. from the tail or, if the hide be exceptionally small, at a less distance; this loses us 25 per cent more, leaving us for cutting into belting a "bend" which constitutes less than 50 per cent of the original hide.

This bend has now to be curried, i. e., given a supplementary grease-tannage; set out—to give a smooth flat piece of leather—and then stretched. The stretching is done on frames in which the wet leather may be clamped and subjected to so much tension as desired, the leather being allowed to dry under tension on the frames so that an additional stretch resultant upon the natural shrinkage of the leather in drying is imparted to the leather. Before being stretched the bend is usually cut into a center and two side pieces, inasmuch as the center portion being more close fibred will not stretch as much as the side pieces and by being divided as above the leather can be stretched more in accordance with its capacity. After stretching the leather is rolled and glassed to improve its looks and is then ready to go to the stock room.

When the leather is received in the stock room, it is sorted according to weight or thickness—which in this connection are practically synonymous terms—into extra heavy, heavy, medium and light, and then packed down for future use. The sides are packed in square piles, alternate layers at right angles, to keep the stock flat and straight and allow of a circulation of air through the pile, thus aiding and hastening the seasoning process. This seasoning is an often neglected but most desirable operation, for the use of well seasoned leather is as important in the manufacture of belting as the use of well-seasoned lumber is in building. Belts made from well-seasoned stock stretch less and more uniformly, retain their elasticity and wear longer than belts from green stock.

From the stock room the leather goes to the belt shop where its manufacture into belt takes place. The first step in this process is to straighten one edge of the leather. Next it is cut into strips of various widths by passing between a rapidly revolving circular knife and a guide, the strips being graded for width and roughly for quality as they come from the knife, and then stored in racks. From these racks the leather goes to the sorters by whom it is most carefully graded, both for thickness and quality, and on their expertness depends the maintenance of the standard set for each brand of belt. Accurate judgment of quality depends on wide experience in handling leather and a good all-round knowledge of the specific characteristics of the leather in different parts of the hide, for it is a fact that no two square inches of hide are precisely alike.

Quality, however, is very elusive of definition when one tries to imprison it in the confines of a specification and the buyer is fully as likely to be well served if he states his needs and trusts to the honesty of an established and reputable house as if he attempts to be his own judge. The author has in mind a large railroad buying belting accord-

ing to a specification which called for the leather to be cut from strictly first quality belting butts and they were getting it, *necks* and all. Inasmuch as a belt is no better than the poorest strip in it, similar to the chain that is no stronger than its weakest link, it may be imagined how well they were being served. Later when the author's company had an opportunity to supply this railroad with some belting, we were rather chagrined to have it rejected by the railroad inspector. Some rolls of stock belt of a grade distinctly inferior to that first offered were then submitted and accepted by the inspector with a cheerful response: "That's what we want; why didn't you give us that at first?" For our own ultimate good we have been trying to educate that railroad on this subject of quality in belting.

Returning to the process of manufacture, after the strips have been sorted, they then go to the *fitters* to be matched and have the laps marked. Pieces cut from the right side of the hide are matched with pieces cut from the left side, because all strips which are not backbone center pieces will stretch in a curve if subjected to a sufficient strain. Narrow strips from a properly stretched side, merely as a result of the stripping, contract to a slight curve. Belts made by joining alternately rights and lefts will roll out in a curve on the floor but will run true upon the pulleys, while belts in the construction of which no attention is paid to the matching of rights and lefts will roll out straight on the floor but will invariably stretch crooked if subjected to sufficient tension on the pulleys. Not all belts show these characteristics noticeably because not all belts are required to transmit sufficient load to develop them early enough in the life of the belt for them to attract attention.

The laps are marked according to the thickness of the stock and usually range between 4 in. and 10 in. in length. Laps must be longer on the shoulder end of the piece because hides become thinner, taper off faster, near the shoulder than near the rump, and longer laps are needed therefore to maintain a uniform thickness of belt. Shoulder ends are joined to shoulder ends and butt to butt because the length of the laps match better, the thickness is more uniform, the stock is similar in quality and the component parts will therefore wear and stretch more uniformly. The laps are next scarfed and prepared for cementing.

The usual cement employed to stick the laps has for its basis animal glue. Each manufacturer is likely to have his own pet formula calling for certain additions to the glue solution and particular methods of compounding, but they all look much alike. By this it is not meant to disparage the cement, for a cement that will hold as long as the leather will wear, is a necessary component of a quality belt. About twelve years ago saw the beginnings of the now indispensable waterproof cement. Laps stuck with this are absolutely unaffected by water, either cold or hot. Whatever cement is used the process of *sticking* is the same in its essentials. The surfaces of the leather to be joined are coated with the cement, put together in their final position, placed between the plates of an hydraulic press and subjected to heavy pressure. From the presses the belt goes to the inspector and then to stock.

The above description applies more particularly to single belting, but the processes are much the same if double or three-ply belting is to be made. A liberal quantity of stock which has been scarfed and the flesh side of which has been cleaned up with a scraper to remove grease, loose flesh, etc. (this being the side which is cemented) is placed upon the fitter's bench. He matches these together on a smooth surface against wooden blocks which are his standard of thickness, the pieces being matched to secure as uniform thickness as possible and so that the laps of one ply come about half way between the laps of the opposite ply.

In conclusion, I wish to emphasize the fact that the idea that a belt is a belt and one need merely cut off a piece of the requisite length and put it on the pulleys is no longer tenable. Proper mechanical conditions and adaptation of belt to drive are just as essential to economy of operation as is the suiting of a motor to the work it has to do. As illustrating the first might be mentioned a three pulley quarter-turn drive with fixed idler that came to our attention. This required an 11 in. belt and was called upon to transmit 100 h.p. The best belt procurable lasted about two months on this drive. Changes in the plant demanded more power from the drive and it was altered to a five-pulley quarter-turn, which necessitated the use of nearly three times the former length of belt. A belt an inch wider is delivering double the horse-power and is good for at least ten years.

Returning to the railroad, their theory of operation was to keep rolls of belt in stock and cut off a length as it was needed. On one machine of which they had record, the average life of a belt was six weeks. Our belt man succeeded in securing the installation of a belt suited to the drive and at last accounts this belt had been in operation over six months and was apparently then in perfect condition.

Another illustration of suiting the belt to the drive: A customer complained that an 18 in. edger belt furnished him was not working satisfactorily and one of our belt men investigating the conditions, found that at the high speed at which the belt travelled, the load was not sufficient to keep the belt down on the pulleys, the edges raising. The belt was narrowed two inches to 16 in. and did the work perfectly. An opposite case was that of a 6 in. light double belt on a high speed drive, long centers, power off and on frequently. The belt jumped so badly it could not be used. A heavy double was substituted and the trouble ceased at once.

The weave room in a cotton mill was belted with medium weight first quality belts and the plant was not a paying proposition. A study of conditions convinced our belt engineer that they were using too light a belt and the belts were replaced with heavier first quality belts, and the plant was able to pay dividends.

Another similar illustration: Our salesman recommended a light double belt for a mill drive, the master mechanic of the mill insisting on a heavy single. There were several similar drives, so one of each was installed. The record of the belts was that the double was taken up and shortened 2 in. five days after installation and not touched again when this record was completed, while the single was shortened 2 in. the day installed, $2\frac{1}{2}$ in. two days later, 4 in. three days after this, 3 in. more sixteen days later, 3 in. more forty-six days later, and 5 in. again after 29 days more, when it was practically worn out.

The subject has been so large for the time at disposal that this talk may have been much cursory and little interesting. It however may have served its purpose if it has shown you something of the problems of the business and of its ramifications—that many of its simplicities are really complexities.

# AN INVESTIGATION OF THE GAS-PRODUCER POWER-PLANTS IN NEW YORK CITY AND VICINITY

BY C. M. RIPLEY,[1] NEW YORK

Non-Member

THE object of personally visiting all the gas producer plants in New York City and its environs was to acquaint the author with the progress which had been made in the use of gas producer power plants and the present status of the industry as applied to a large city and its suburbs. It had been suggested that most of the information available to owners and engineers on this subject emanated from the sales departments of various manufacturers; also that these manufacturers report only upon plants which they themselves install and then upon only the more successful ones; and that an unbiased investigation might be interesting to the Gas Power Committee of the American Society of Mechanical Engineers, and also to those of the business community who operate properties involving large annual expense for heat, light and power.

The investigation covers the size, age and performance of the gas producer plants and a census was taken of owners' opinions regarding repairs, labor and depreciation. The three different phases of this investigation are as follows:

I. A census recording owners' opinions. (Table 1).
II. Technical data, showing capacities, performances, etc. (Table 2).
III. General information from personal inspection and interviews.

On Tables 1 and 2 plants are arranged according to their size, i. e., from 1000 h. p. down to 30 h. p. of producer capacity. In the division of general information the plants are taken up according to their age in service, i. e., from sixteen years down to less than one year.

## CENSUS OF OPINIONS

To each of the owners of gas producer plants in this district was written the following letter:

Gentlemen:

I wrote you early in the month requesting a "yes" or "no" answer to these questions about your gas producer plant:

Ques. No. 5. Are repairs in excess of your expectations?
" No. 6. Is depreciation in excess of your expectations?
" No. 7. Is labor charge in excess of your expectations?
" No. 8. Are you availing yourselves of the heat in jacket water and exhaust?
" No. 9. If you were to construct another building for similar uses would you again install a gas producer plant?

The idea of this investigation of all the gas producer plants in New York City and in near-by towns in the Metropolitan District is to ascertain the progress made by gas producers, their present status and the general opinion of those who operate them.

In return for this information I will be pleased to send you a copy of my complete paper with charts and the result of the census. It will be interesting for you to know what the other users of gas producer plants think of this system of power, and in the future if anyone asks information of you about your plant you can refer them to the library of the American Society of Mechanical Engineers, where in all probability their questions will be answered.

Thanking you in advance,

Yours very truly,
(Signed) C. M. RIPLEY.

The answers to these questions are tabulated in Table 1 and lead to a most interesting conclusion as to the present status of large gas producer plants. As a constructive criticism it is to be hoped that manufacturers will profit by a study of this chart and that their product will be improved where weakness has been shown. That this will be the case in the next few years the author feels confident.

The fact that 78 per cent of the gas producer plants in this territory gave definite answers to a majority of the four questions indicated at the top of the chart, is very gratifying. It will be noted that 86 per cent of the large plants, i. e., 250 h. p. and larger, answered the questions fully, whereas but 74 per cent of the small plants gave answers to these questions.

In regard to question No. 5, it is interesting to note that 80 per cent of the large plants report repairs in excess of their expectations and that only 6 per cent of the small plants so reported. The satisfaction with the small plants in regard to this question is indicated by the fact that 94 per cent of them answer "no."

In regard to question No. 6, 56 per cent of the large plants report depreciation in excess of their expectations, while 94 per cent of the small plants report the contrary.

In regard to question No. 7, 50 per cent of the large plants report attendance costs in excess of their expectations, while 88 per cent of the small plants do not find this to be the case.

Question No. 9 asks for opinion as to installing a gas producer plant in case a new factory were to be built. 50 per cent of the larger plants answer "yes," 30 per cent "no," and 20 per cent are doubtful. Should this 20 per cent be interpreted as meaning "yes," then the large plants would indicate 70 per cent favorable answers against 86 per cent favorable answers from the small plants. Should "doubtful" be interpreted as "no," then 50 per cent of the large plants may be considered unsatisfactory as against 14 per cent of the small plants.

Attention is invited to this Table as it gives a tabular measure of satisfaction and dissatisfaction. The answers as shown to the four questions constitute practically a curve in which satisfaction is plotted against size, and can be visualized without difficulty.

## TECHNICAL DATA

In Table 2 will be found information as suggested for convenience of reference and comparison, from which it will be gathered that there are fifteen gas producer plants in New York City, and a total of thirty-three in operation in the Metropolitan District. This is in addition to two

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Presented at the New York local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on November 9, 1915.

experimental gas producer power plants, three gas producer plants used for furnaces only (not in connection with power plants), and seven gas producer power plants which have been abandoned.

*Kind of Coal Used.* It will be noted that only two of the thirty-three plants referred to above are using bituminous fuel, all of the rest using either pea or buckwheat anthracite.

One general impression obtained by the author is that only slightly more fuel is used in these plants for a 24-hour run than for a 12-hour run. This is due to the following, as stated by one expert in gas producer operation:

Table 1 Census of Owners Opinions

| No. of Plant | H.P. Not answered | H.P. answered | Ques. 5 Yes | Ques. 5 No | Ques. 6 Yes | Ques. 6 No | Ques. 7 Yes | Ques. 7 No | Ques. 9 Yes | Ques. 9 No | Ques. 9 ? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 1000 | + | | + | | + | | | | + |
| 2 | 1000 | New plant just started | | | | | | | | | |
| 3 | | 700 | | + | | + | | + | + | | |
| 4 | | 600 | + | | + | | + | | | + | |
| 5 | | 600 | + | | + | | | + | + | | |
| 6 | | 600 | | + | | + | | + | + | | |
| 7 | | 400 | + | | | + | | + | + | | |
| 8 | 400 | | | | | | | | | | |
| 9 | | 300 | + | | + | | + | | | + | |
| 10 | | 300 | + | | | | | + | + | | |
| 11 | | 275 | + | | | + | + | | | | + |
| 12 | | 250 | + | | + | | + | | | + | |
| 13 | | 200 | | + | | + | | + | + | | |
| 14 | | 200 | + | | + | | + | | | + | |
| 15 | | 200 | | + | | + | | + | + | | |
| 16 | | 200 | | + | | + | | + | + | | |
| 17 | 200 | | | | | | | | | | |
| 18 | | 180 | | + | | + | | + | + | | |
| 19 | | 150 | | + | | + | | + | + | | |
| 20 | | 150 | | + | | + | | + | | + | |
| 21 | 125 | | | | | | | | | | |
| 22 | | 150 | | + | | + | | + | | | |
| 23 | | 100 | | + | | + | | + | + | | |
| 24 | | 100 | | + | | + | | + | + | | |
| 25 | 100 | | | | | | | | | | |
| 26 | | 50 | | + | | + | | + | + | | |
| 27 | | 50 | | + | | + | | + | + | | |
| 28 | | 50 | | + | | + | | + | + | | |
| 29 | 56 | | | | | | | | | | |
| 30 | | 50 | | + | | + | | + | + | | |
| 31 | | 50 | | + | | + | + | | | + | |
| 32 | 40 | | | | | | | | | | |
| 33 | | 30 | | + | | + | | + | + | | |
| Total | 1921 | 6935 | 9 | 17 | 6 | 19 | 7 | 19 | 17 | 6 | 2 |
| Per cent of number | 22 | 78 | 35 | 65 | 24 | 76 | 27 | 73 | 68 | 24 | 8 |
| % 250 HP or larger | 14 | 86 | 80 | 20 | 56 | 44 | 50 | 50 | 50 | 30 | 20 |
| % 200 HP or smaller | 26 | 74 | 6 | 94 | 6 | 94 | 12 | 88 | 86 | 14 | 0 |

It is common practice in the majority of gas producer plants to remove more or less green fuel with the ash, when cleaning fires. Usually the percentage of combustible matter in the ash grows smaller as the hours of operation increase and the load on the producer approaches a maximum.

In a producer that is underloaded and running on an average of 10 hours in the twenty-four, combustion is not rapid enough to allow for lowering the entire fuel bed, and more or less green fuel is removed by the average operator, this being an easy and convenient way of maintaining the fire in a good gas-making condition.

A skilled operator can usually obviate this difficulty by studying his fire and cleaning it according to the position and amount of the ash. His method would be approximately as follows: A normal fuel bed produces an ash deposit, the part of which in contact with fuel, has the shape of a bowl. This is due to the draft following the sides of the producer and in case of an underload on the fire and the draft being reduced, a larger percentage follows the sides than would under full load conditions.

This means that the operator must clean the side walls thoroughly and practically leave the centre of the fire untouched. As the majority of producers are so designed that this is a task which only a skilled operator can perform successfully without removing considerable green fuel mixed in the ash, the average plant shows a large amount of combustible matter in the ash.

Different types of producers are more or less adapted to meet these conditions. The type designed in such a manner that the fuel bed rests on a solid ring on the side and a shaking grate in the centre, meets the above conditions better than any other. It enables the operator to remove the wall ash a little at a time and by poking around the wall, between the removals, to gradually lower the bed at this point to the proper level, without losing any good fuel. After this is done, by shaking the grate, the centre also can be cleaned.

Where the fuel bed rests entirely on a shaking grate, if the walls are cleaned in the manner described, green fuel is shaken down when the centre is lowered. If the grate is resorted to to lower the entire fuel bed, much good fuel is removed from the centre before the walls are properly clean.

In producers using a turn-table and bars to scrape off the ash accumulation the same result follows. In producers having a water seal, and relying on the cone effect of the ash bed around a tuyere, to allow for the removal of ash of the shell, runs occur owing to the fact that the operator cannot see the fire as he works it, and does not know at any time the exact position of the fire. All these difficulties may be more or less overcome by a skilled operator who studies his fire.

The fact that a producer can be run 24 hours with much less fuel in proportion to the load carried, than for 10 hours, is due to a great extent to the foregoing. A normal producer, if properly handled, should show a standby loss of not over 5 per cent of the grate rating. Also standing idle tends to make the fire climb into the fuel magazine and due to the heat generated, cause the operator to pull more or less fuel in order to permit the addition of more green fuel to cool the top of the producer.

Any moisture entering the bottom of the producer when it is standing idle, tends to drive the fire to the top and leave the bottom filled with partly consumed and useless fuel.

These conditions may not apply in all cases but nearly all fuel waste is traceable to them (in one form or another) or to poor design.

*Height.* It will be noted that considerable headroom is needed for the gas producers even in the small plants. This, however, has been overcome in two plants by locating the producer out-doors, thus saving excavation, and with apparently no bad results. In regard to the space occupied by the producers, it is surprisingly small in relation to the amount of power obtained from them.

*Attendance.* It will be noted that the anthracite plants seldom need over six charges a day even for a 24-hour run, and the cost of firing is small indeed. In fact operating men consider the firing, as far as the amount of time is concerned, a great advantage as firemen can be useful at other work during a vast majority of the time. In many cases the engineer does the charging himself as it requires so little time and effort, especially with the electric hoist or other coal elevating devices. The removal of the ashes under these conditions is left to a laborer. The operation of plants of 300, 400 and 600 h. p. with the consumption of one, two, three and four tons of coal per day is to be noted, several cases showing these results in a 24-hour run.

## GAS PRODUCER POWER PLANTS
### NEW YORK CITY AND METROPOLITAN DISTRICT

| No of Plant | NAME OF CO. | CITY | PRODUCERS | TOTAL HP. | ENGINES | TOTAL HP. | DYNAMOS | TOTAL KW. | VOLTAGE | TOTAL COST | HT. OVER ALL | SPACE | NO CHARGES DAILY | MAX. LOAD | AVE. LOAD | HOURS RUN DAILY | FUEL DAILY | FUEL PER HP-HR. | LUBRICANTS | ATTENDANCE | AVE. REPAIRS YEARLY | AGE (YEARS) | KIND OF COAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ATHA TOOL CO. | NEWARK, N.J. | 2 | 1000 | 4 | 640 | 4 | 325 | 250 | 75000 | 40 FT | P 30x30 | 250 | * | * | 12 | 8 TONS | | | | | 5 | BIT |
| 2 | L.O.KOVEN BROS | JERSEY CITY | 2 | 1000 | 1 | 150 | 1 | 100 | 250 | | 50 | 70x75 | | * | * | | | | | | | ½ | BIT |
| 3 | HORTON ICE CREAM CO. | N.Y.CITY | 2 | 700 | 6 | 675 | 3 | 450 | 250 125 | 55000 | 25 | P 24x30 | | ** | ** | 24 | 4 TONS | 1.35 | | | | 5 | BUCK |
| 4 | AMER.COTTON OIL CO. | JERSEY CITY | 3 | 600 | 2 | 600 | 2 | 400 | 125 | | 40 | P 22x45 | 3 | | 6000A | 24 | 9½ | | | | | 2 | PEA |
| 5 | SWIFT & CO. | N.Y.CITY | 3 | 600 | 4 | 400 | 4 | 300 | 250 | | 30 | P 20x20 | 4 | ** | ** 450A | 24 | 3½ | | | 6 | | 8 | PEA |
| 6 | NATIONAL METER CO. | N.Y.CITY | 2 | 600 | 3 | 550 | 3 | 350 | 125 | 30000 | 30 | P 40x16 | 2 | | 225 KW | 11 | 3 | 1.7† | | | | 9+3 | BUCK |
| 7 | PHOENIX TUBE WKS. | N.Y.CITY | 2 | 400 | 4 | 535 | 3 | 300 | 115 | | 20 | P 20x20 | 1 | | | 10 | 1.1 | | | 1 | | 13 5+4 | PEA |
| 8 | ERIE R.R. | JERSEY CITY | 2 | 400 | 7 | 552 | 3 | 230 | 110 2400 | | 35 | P 20x40 | 8 | *** | *** | 24 | 2 | | | 3+ | | 16 | PEA |
| 9 | CASTLE ICE CREAM CO. | NEWARK, N.J. | 1 | 300 | 1 | 300 | 1 | 200 | 125 250 | 18000 | 20 | P 20x30 | 4 | 500A | 750A | 24 | 3½ | | 90 gal per Mo | 4 | $1500 | 1 | " |
| 10 | MERGENTHALER LINOTYPE CO | N.Y.CITY | 1 | 300 | 1 | 300 | 1 | 200 | 125 250 | 33000 | OUT DOORS | P 13x15 | 2 | | | 10½ | 2⅓ | 2.0† | | | | 2 | " |
| 11 | MAX AMS MACH. CO | MT.VERNON, N.Y. | 2 | 275 | 2 | 175 | | | | 20200 | | | | | 142 HP | 11 | ¾ | 1.12 | | | | 8 | " |
| 12 | DE LA VERGNE MACH. CO | N.Y.CITY | 1 | 250 | 1 | 75 | 1 | 25 | 115 | | 30 | P 15x25 | 1 | *** | *** | 11 | ¼ | | | | | 7 | BUCK |
| 13 | KEYSTONE WATCH CASE CO | JERSEY CITY | 1 | 200 | 2 | 170 | 2 | 125 | 220 | 15000 | 20 | P 12x18 | 21 | * 400A | * 500A | 11 | 1½ | | | 2 | $300 | 7 | PEA |
| 14 | AUTO PRESS CO. | COLLEGE PT, L.I. | 1 | 200 | 1 | 135 | 1 | 100 | 240 | | 20 | P 14x14 | 1 | 1888 KWH. per wk | 80 KW | 9 | 1¼ | | | $25 per week | | 5 | " |
| 15 | JOHN THOMPSON PRESS | L.I.CITY N.Y. | 1 | 200 | 2 | 185 | 3 | 175 | 250 | | 20 | P 12x20 | 8 | 165 HP | | 11 | ½ | 1.29 | | $43 per week | | 9 | " |
| 16 | ACME ELEC. GARAGE | N.Y.CITY | 1 | 200 | 3 | 300 | 3 | 200 | 125 250 | 30000 | 20 | 40x40 | 2 | 2000 KWH per day | 1630 KWH per day | 24 | 2 | | | 2 | | 1+4 | BUCK |
| 17 | T. SCHRIVER & CO. | HARRISON, N.J. | 2 | 200 | 3 | 150 | 6 | 69 | 250 | | 15 | 30x30 | | | | 9½ | | | | | | 8 | PEA |
| 18 | CHAS. MUNDT | JERSEY CITY | 1 | 180 | 2 | 175 | 1 | 5 | 230 | 5500 | | | 2 | *** | *** | 14 | ⅓ | 1.12 | | 1- | | 8 | " |
| 19 | GEO.F.HEINRICHS | N.Y.CITY | 1 | 150 | 2 | 270 | 2 | 174 | 125 250 | | 20 | P 12x12 | 8 | | 110 KW | 16 | 11 | | | 1+ | | 5 | " |
| 20 | LUDWIG PIANO CO. | N.Y.CITY | 1 | 150 | 1 | 100 | 1 | 75 | 230 | | 15 | P 10x25 | 6 | | | 11 | 1.1 | | | 2 | | 7 | " |
| 21 | STROBELL & CRANE | NEWARK, N.J. | 1 | 125 | 1 | 69 | 1 | 50 | 125 | | 14 | 11x25 | 6 | *** 250A | *** 300A | 10 | ½ | | | 1+ | | 9 | " |
| 22 | HOOTEN COCOA CO. | NEWARK, N.J. | 1 | 150 | 1 | 150 | 1 | 100 | 220 | 13000 | 25 | P 25x25 | 6 | 400A | 500A | 11 | ½ | 0.94 | 2 gal Daily | 1+ | $33 | 5 | " |
| 23 | HAWLEY & HOOPS | N.Y.CITY | 1 | 100 | 1 | 80 | 1 | 75 | 230 | | 14 | P 10x20 | 5 | | | 10½ | ½ | 1.12 | | 1 | | 9 | " |
| 24 | WINELANDER & JACKSON | N.Y.CITY | 1 | 100 | 1 | 85 | 1 | 15 | 110 | | 18 | P 20x20 | 1 | *** | *** | 12 | ½ | | 2 qts daily | 1- | $79 | 4 | " |
| 25 | UNIVERSAL METAL BED CO | N.Y.CITY | 1 | 100 | 1 | 100 | 1 | ¼ | 115 | | 17 | P 26x16 | | *** | *** | 10 | ½ | | | 1 | | 8 | " |
| 26 | THOS WRIGHT WAGON SHOP | JERSEY CITY | 1 | 50 | 1 | 35 | 1 | 7 | 115 | 3640 | 15 | 12x30 | 4 | *** | *** | 9½ | ⅕ | | $2 per Mo | 1- | $52 | 9 | " |
| 27 | McCABE HANGER CO. | N.Y.CITY | 1 | 50 | 1 | 50 | 1 | 30 | 250 | | 15 | 25x25 | 4 | 180 | 120 | 10 | ⅔ | | | $70 per Mo | | 8 | " |
| 28 | PIRIKA CHOC. CO. | N.Y.CITY | 1 | 50 | 1 | 45 | 1 | 10 | 115 | 4200 | OUT DOORS | P 15x15 | 1 | ** | ** | 11 | ¼ | 1.12 | $15 per Year | 1- | $10 | 9 | " |
| 29 | ERIE R.R. | CROXTON, N.J. | 1 | 56 | 1 | 56 | | | | SEC HAND | 25 | 20x30 | | *** | *** | | ¼ | | | 1- | | 3 | " |
| 30 | LEIMAN BROS. | NEWARK, N.J. | 1 | 50 | 1 | 40 | 1 | 5 | 115 | SEC HAND | 12 | P 12x12 | 3 | | | 11 | ¾ | | | 1- | | 8 | " |
| 31 | N DRAKE CO. | NEWARK, N.J. | 1 | 50 | 1 | 50 | | | | | 18 | P 10x25 | 1 | | | 11 | ½ | | | 1- | | 9 | " |
| 32 | ALLSOPP BROS. | NEWARK, N.J. | 1 | 40 | 1 | 40 | | | | | 12 | P 6x15 | 3 | *** | *** | 11 | ⅓ | | | 1. | | 7 | " |
| 33 | GEN'L CEMENT PROD. CO. | L.I. | 1 | 30 | 1 | 28 | 1 | 18 | 115 | 3300 | 15 | 10x10 | 1 | *** | *** 50A | 24 | ⅛ | | $5 per Mo | 1 | $70 | 9 | " |
| | **EXPERIMENTAL** | | | | | | | | | | | | | | | | | | | | | | |
| | Stevens Institute | Hoboken, N.J. | 1 | 30 | 3 | 29 | 1 | 7½ | 125 | | | | | | | | | | | | | | |
| | Stand Motor Const Co | Jersey City | 2 | 300 | | | | | | | | | | | | | | | | | | 7 | |
| | **FURNACES ONLY** | | | | | | | | | | | | | | | | | | | | | | |
| | Cork Insulating Co | Jersey City | 2 | 400 | | | | | | | | | | * | | 24 | 12 | | | 2 | | 2 | ½ pea ½ buck |
| | Hyatt Roller Bearing Co | Harrison, N.J. | 3 | 1500 | | | | | | | | | | * | | | | | | | | 1 | Bit |
| | Crucible Steel Co. | Harrison, N.J. | 2 | | | | | | | | | | | * | | | | | | | | | |
| | **PRODUCERS DISCONTINUED** | | | | | | | | | | | | | | | | | | | | | | |
| | N J Adamant Mfg Co | Harrison, N J | 1 | 50 | 1 | 50 | | | | Sold | | | | | | | | | | | | 3 | Pea |
| | Harper Brick Co | Harrison N J | 1 | 27 | 1 | 27 | | | | Sold | | | | | | | | | | | | 2 | " |
| | Newark Spring Mattress Co | | 1 | 50 | 1 | 38 | | | | Sold to Leiman Bros | | | | | | | | | | | | 4 | " |
| | C E Hertlein | N Y City | 2 | 285 | 3 | 300 | | | | Sold - 2 plants - both failed - Now use Steam Elect | | | | | | | | | | | | 1 | " |
| | Cameron Mach. Co | N Y City | 1 | 50 | 1 | 50 | | | | Sold | | | | | | 9 | ⅓ | | | 1 | | 3 | " |
| | Manhattan Screw & Stamp Wks | N Y City | | | | | 1 | 75 | | For sale Firm retired from business | | | | | | | | | | | | | |
| | Adnance Machine Co. | N Y City | | | | | | | | Second hand - Never unboxed - For Sale | | | | | | | | | | | | 2 | |

†Per kw-hr.

* = Furnace Gas Load   ** = Belted Refrigeration Load   *** = Belted Power, Pumps, Compressors etc,   P = Space for Producers only

TABLE 2 TECHNICAL DATA OF GAS PRODUCER POWER PLANTS IN NEW YORK

As a general impression, it would appear that the importance of skill on the part of the engineer in charge is greater than estimated by the average salesman, and several owners have engaged second and third class operatives and paid the price to their sorrow. To a large extent this error is, in the author's opinion, to be laid at the door of the sales departments of the manufacturers, and it is hoped that they will advance their interests by being more careful as to their claims in the future. It is true that the firing of the coal is a very small matter, but the care of the gas engine and producer cannot be entrusted to a third class man or a laborer, as some have vainly attempted to do.

Some owners are using the unconsumed coal in the ashes for firing boilers, and one owner carries it to a point that he not only heats his factory but his residence with the mixed ash and coal removed at the end of the day's run.

### GENERAL INFORMATION

*The Oldest Gas Producer Plants.* The oldest gas producer plants in operation in the territory investigated is at the Erie Railroad Company's terminal in Jersey City, N. J. For 16 years the same producers (Wood pressure type) have been in use and while the Railroad Company refused to contribute to the author's census of opinions, their satisfaction may be gathered from the fact that they have made additions to this power plant upon two separate occasions. Two 90 h. p. Otto engines were later supplemented by three Otto and one Westinghouse engines, and later again augmented by another Westinghouse engine. William S. Young is the mechanical foreman of this plant. Both alternating and direct current electricity is generated and both direct connected and belted drives are used.

Another old plant is that at the Phoenix Tube Works, Brooklyn, which for thirteen years has had no other source of power than gas producer plants. They use one Smith and one Tait suction producer, and as in the previous instance, have twice enlarged their plant. They have, for attendance, but one man who does his own charging and that but once per day of 10 hours. If they wish to run at night they run one of their engines with city gas. The engines are direct-connected to electrical generators.

In the tenth year of service is a plant owned by Thomas Wright, wagon maker, in Jersey City, N. J. In an interview Mr. Wright said: When we purchased electricity it cost $6.25 per day for power. When we purchased street gas and ran our gas engine it cost $4.85 per day for power. With the present plant it costs $1.00 per day for power. I wish to go on record as saying that had I not invested in this economical plant when business was good in 1905, I would have been forced to retire from business.

This plant has had several shut-downs due to careless handling, and in his letter Mr. Wright states that the gas producer plant is profitable but the man taking care of same must be useful and interested. He also states that his repairs from 1906 to 1914 have been so small that he hardly notices it. Also, that the labor charge is not excessive, considering what they would have had if operating a steam engine. His engine is chiefly belted to the load.

*Plants in Ninth Year of Service.* The Pirika Chocolate Co., in Brooklyn for nine years, have depended on their gas producer plant for power and for a great deal of their heat. Mr. George C. Stout says, "If all gas producer plants ran as ours has run, there would be no other kind of power plant in the world." This plant emits no smell, the producer being located out-doors, and they state that the increased consumption of fuel during the winter months, which they attribute to the location of the producer, is only thirty pounds, or 6c. per day. The firing requires one hour per day of a ten dollar a week man. The repairs to the producer outfit for eight years have been about $40.00 and the repairs to the engine have cost about $50.00.

Twenty-eight kettles are heated at the Pirika plant by forcing the cooling water from the jacket of the engine through the kettles by means of a small electric-driven turbine pump, using one ampere. The cooling water goes into the jacket at 160 deg. and emerges at 190 deg. fahr. It is quite an achievement to run a factory building 35 x 110 ft., three stories and basement, and burn only 75 tons of fuel per year. Mr. Stout opened his records for years back and showed the average to be no greater than as shown above. Smith producers and Nash engines are used in this plant, belt-connected to the load. They used a barrel of oil a year for engine lubrication.

Hawley & Hoopes, another candy manufacturer, on Manhattan Island, New York, have used a gas producer plant for nine years. They also have a steam plant and electric connection from the street for night work. They use Wood producers and Westinghouse engines, direct connected, and the plant gives entire satisfaction.

Strobell & Crane, jewelry manufacturers in Newark, N. J., who occupy a building 75x160 ft., five stories high, operate an Industrial gas producer and Westinghouse engine, direct connected to a generator and belted to other power. The engine has run nine years and ran six years without the cylinder heads being taken off. They also have a connection with the street electricity.

The John Thompson Press, Long Island City, has operated a gas power plant for nine years. This power plant is in a separate building and the plant gives satisfactory service. The factory building is 80 x 165 ft., three stories in height. A Wood producer and Nash gas engine, direct connected to the generator, are used. George W. Day is chief engineer.

The National Meter Co., of Brooklyn, have a gas power plant comprising Smith producers and Nash engines, direct connected, nine years old, which was enlarged three years ago and again two years ago. The building is 50x315 ft., four stories high, and the grounds surrounding it are 200x500 ft. This plant developed 12,200 kw-hr. per week of 55 hours and is only charged twice per day. An electric hoist is used to advantage for charging each of the producers. They sold their steam engine and have no connection with the street electricity.

N. Drake, at Newark, N. J., has a nine-year-old plant in his coal and wood yard and grain elevator. They have had no trouble since the first three months and charge but once a day for an 11-hour run. The attendance is less than one-half of one man's time in addition to the supervision of Arno Morgner, foreman. The engine is belted connected to the load.

*Plants in Eighth Year of Service.* Leiman Brothers' pump works at Newark, N. J., give an interesting example of the reincarnation of a dead gas producer plant. These people for three years have operated with entire success and satisfaction a plant which was an utter failure during the five years it was at the Newark Spring Mattress Co. The Mattress Co. abandoned the plant in disgust and changed to

street electricity at less than three cents per kw-hr., but refused to state the exact rate which induced them to abandon the unsatisfactory plant.

Mr. George Leiman, of the above company, obtains from the ash of his gas producer enough coal throughout the year to heat his factory and one other building. The attendance of this plant requires two hours daily of a helper and the careful attention of the foreman of the shop, who is a first-class mechanic. Mr. Leiman states that they have less trouble than with the ordinary steam plant and is entirely satisfied with the outfit.

Another eight-year old direct-connected plant is at the Max Ams Machine Co., of Mount Vernon, N. Y. They wrote in 1913, "Very well satisfied with the system and would not exchange for a steam plant, nor will we consider a steam plant when we are in need of an additional plant." Their answer to the census in 1914 indicates a growing interest in the semi-Diesel oil engine. They use the De La Vergne gas engine, which the De La Vergne Co. state they no longer manufacture.

The McCabe Hanger Co., on Manhattan Island, have used for eight years an Otto engine and producer. This is of low speed and noisy, but is very compact and emits no smell. The owner has a well for cooling water. In the eight years of operation, he claims to have had but one shut-down due to the engine and no shut-down due to the producer. There were twelve stoppages, however, due to bad bearing lubrication. Mr. McCabe's opinion is that producers below 100 h. p. are more satisfactory than those over 100 h. p. Mr. McCabe's plant is less than 100 h. p., direct connected.

Swift & Co., in the Bronx Borough, N. Y., have operated a large plant for generating electricity and refrigeration for eight years. Smith suction gas producers and Rathbun-Jones engines are used, direct connected to generators. The refrigerating machines are driven by motors. The plant is never shut down. Mr. W. F. Frazer, the chief engineer, says that, properly cared for, the labor charge is the same as a steam plant of the same size. A low pressure heating system is installed in the upper portions of the building. They are availing themselves of the heat in the jacket water and exhaust only for heating a small amount of water required as a spray in the producer.

Charles Mundt, of Jersey City, whose business is to punch metals up to ½ in. in thickness, has a factory 50x250 ft., two stories in height, and has operated on gas power for eight years. The man who cares for the engine and producer works regularly in the shop. This plant has been enlarged and improved, and the old engine is used with city gas as auxiliary. Otto producers and engines are used, belt-connected to the load.

T. Shriver & Co., Harrison, N. J., conduct an iron foundry and machine works and for eight years have used gas producer power. They charge but twice during the day's run and have one Otto producer and engine and one Westinghouse producer and engine, both belt connected to the load. They did not answer the census.

The Universal Metal Bed Co., Brooklyn, N. Y., lease a building and producer plant formerly operated by the Star Engravers' Supply Co. This plant is eight years old. Mr. R. J. Zapkin is superintendent, and supplied this information.

*Plants in Seventh Year of Service.* The Keystone Watch-case Co., Jersey City, N. J., have for seven years operated a Harvey producer and two Westinghouse engines, direct connected to electric generators. They have had no shutdowns in the last several years. They also use producer gas in the brass foundry and in ten forges. The engine room is cool and light and has almost no odor. They have a steam auxiliary.

The De La Vergne Machine Co. have operated a gas producer plant for seven years, but state that they have ceased manufacturing them.

The Ludwig Piano Co. have a six-story factory in the Bronx, New York City, and have operated a Koerting gas engine and suction producer for seven years. When inspected they were adding a 200 kw. steam engine, as considerable steam is used in their drying rooms. The chief engineer states that he can start up his plant in 25 minutes, including the making of a fresh fire. The coal withdrawn with the ashes at night from the producer is burned under the boilers. Granville Gibbons is chief engineer. He states that when the producer was being repaired they ran the engine with street gas.

Allsopp Brothers, jewelry manufacturers, of Newark, N. J., have a factory 30x100 ft., five stories high, and have operated a Backus engine and producer for seven years. They are operating apparently satisfactorily in a cool room. The engine is belted to the load and the electricity from the street is purchased for light only. They have gas connection with the street.

*Plants in Sixth Year of Service.* The General Cement Products Co., and the Auto. Fire Protection Co., who are the joint tenants in a two-story 50x100 ft. factory building at Whitestone, L. I., have operated a producer gas power plant for six years. Smith suction producers and Nash engines are used. Mr. Thurston, the chief engineer, states that all machinery is motor-driven. The producer is charged once a day, in the morning, with 250 lbs. of pea coal. At 6 P. M. the shop is closed and locked, leaving the belted engine running alone all night, carrying a 50 amp. night load, which it is claimed has been done for four years. During this time the plant has supplied electric light for a residence, barn, and outdoor lighting on the country estate of R. L. McElroy adjoining. Also, electricity is used for cooking twenty meals per day at the residence. The supply of electricity for this residence, it is claimed, supplants an electric bill of $320.00 per month at an expense of less than $85.00 per month, including interest and depreciation. The residence contains a Simplex No. 11 cooking range, which replaced an old coal range five years ago. When cooking with coal it required two tons per month of $6.00 coal. With the electric range and the increased electric consumption for operating same, the producer burns one ton per month extra at $4.00 per ton. Besides the electric range are three electric irons, three electric hot plates, a waffle iron, one electric toaster and one electric percolator.

*Plants in Fifth Year of Service.* The Horton Ice Cream Co., New York City, who operate an ice cream factory, 200x100 ft., five and six stories in height, have used producer gas for five years. Besides operating forty motors for machinery, they also operate seven electric elevators. The total motor load is 810 h. p. The engine room is cool and quiet, but the producer room is terribly hot. This latter condition is largely because tenants in the apartment houses

nearbly complained of the noise of firing, and in deference to their wishes the company bricked up the producer room at the expense of ventilation. H. J. Ayers is chief engineer. Tait suction producers and Rathbun-Jones engines are used, direct connected to electric generators.

The Atha Tool Co., Newark, N. J., who have been using producer gas power for five years, have five buildings, covering six and one-half acres of ground. This is one of the producer plants in the Metropolitan District which operates on bituminous coal, Loomis-Pettibone suction producers being used. Mr. Hausman, the superintendent, escorted the author through the plant.

The gases from the producers are passed through a vertical boiler before going into the scrubber and dryer. This boiler generates 80-lb. steam pressure, which operates the blower engine, pumping the gas to the outdoor holders. The same producers make water gas and producer gas alternately every few minutes. The water gas is used in the furnace of the forge shop.

Before installing the gas producer plant the Atha Company spent $20.00 per day for coal for the 42 furnaces in the forge room. With the gas producer plant they burn less than eight tons of coal in a 12-hour day, which displaces the old method of heating in the forge room and also gives them about 500 h. p. of Westinghouse engines direct connected to dynamos.

The Hooton Cocoa & Chocolate Co., Newark, N. J., have for five years operated a Fairbanks-Morse producer and gas engine. This is one of the cleanest, coolest, odorless and best appearing plants which the writer has seen. High ceilings, good light, and exquisite cleanliness contribute to the result. One first-class mechanic runs it with the assistance for a few hours daily of a low-priced helper. G. B. Griffith is in charge of the producer engine and dynamo. F. H. Sterner is the steam and refrigerating engineer of the factory. Mr. Griffith states that the repairs on the producer plant in three years have amounted to about $100.00.

A decided novelty in this plant is that the producer apparatus and piping were all painted with aluminum paint, adding to the lightness of the room and establishing a standard of cleanliness throughout. The operator also designed a novel ash pan under the cleaning door with an apron shaped to the curvature of the producer, which prevents the dust and ashes from getting on the floor during the process of pulling the fires. This pan has handles at either end, making it portable and permits the ashes to be entirely removed from the building with ease after each cleaning process.

The Hooten Company also has a belted steam engine not in use. They purchase alternating current electricity from the street for running part of the factory and generate direct current in their gas producer plant.

Mr. George F. Heinrichs, who operates a meat market in Manhattan Island, New York, 120x150 ft., part three and part two stories in height and irregular in shape, has operated with producer gas for five years. This is a quiet running plant with no smell or vibration, and is one of the best plants from the standpoint of operation. Mr. J. Ruf is chief engineer. The Hill-Hupfel suction producer and Struthers-Wells gas engine are used, direct connected to generators. Mr. Ruf thinks that the manufacturers over-rate the producer and also over-rate the engines.

The Auto Press Co., College Point, Long Island, have a factory 60x400 ft., three stories high. Their producer power plant is in the fifth year of service and runs five days per week, nine hours per day. They have had one shut-down due to careless engineer and since inspection have reported more trouble. The engine is belt-connected to the load.

*Plants in Fourth Year of Service.* Winelander & Jackson, who make steel lined brass pipe for beds, etc., have a factory 200x100 ft., one story high, in Brooklyn. The engine is located in a pit at the center of the shop and is belted to the shafting and to a small motor used as a dynamo and furnishing all electric light and power. The engine runs quietly and emits no smell whatever. The tool maker takes complete charge of it and a night watchman cleans the fires at night and charges in the morning. For a 12-hour run they use 1000 lb. of pea coal and for a 24-hour run they use 1500 lb. of pea coal. Mr. E. Ebke is the superintendent. This plant is a pronounced success and has been in operation since July, 1911. A Smith producer and Nash engine are used, with belted connection to the load.

The Acme Electric Garage, 410 East 32nd Street, Manhattan Island, has been enlarged three times since it was installed four years ago. The building in which the garage is located is a nine-story loft building. Wood producers and two Bruce-Macbeth engines, direct connected to generators. When inspected the plant was being increased in size—close to 600 h. p.

*Plants in Third Year of Service.* The Erie Railroad Co. had a gas producer plant in North Paterson, N. J., which was later removed to Croxton, N. J. This gas engine was belted to the shaft and ran satisfactorily with three or four shut-downs in three years. The master car builder stated, "A pail of coal now and then, just like firing a base burner parlor stove." This plant was removed from North Paterson because it was too small for the work. It is belt connected to the load.

*Plants in Second Year of Service.* The Mergenthaler Lintoype Co., Brooklyn, N. Y., have a satisfactory working outfit consisting of a Smith producer and Rathbun-Jones engine. This was one of the plants where the producer was located outdoors. Above it is an electric hoist for charging, which is covered by an ordinary corrugated roof to protect it from the rain. The gas engine is working in parallel with four steam units, all delivering electricity for the operation of the factory. R. J. Meadows is the chief engineer.

The American Cotton Oil Co., Guttenberg, N. J., have operated a plant for two years, consisting of Smith producer and Allis-Chalmers engines, direct connected. They have recently changed from pea coal to buckwheat coal.

Castle's Ice Cream Co., Newark, N. J., have a producer plant in its second year of service. They also have a steam plant. The gas power plant consists of a Smith producer and Nash engine, direct connected to a dynamo.

*Plant in First Year of Service.* L. O. Koven Brothers, makers of stoves, ranges, etc., in Jersey City, are operating two Loomis-Pettibone suction gas producers for bituminous coal and one Westinghouse engine, direct connected.

*Experimental Plants.* Standard Motor Construction Co., Jersey City, installed a gas producer plant more or less as an experimental proposition, with a view to adapting gas producers to marine work. The experiment was not a success. The Loomis-Pettibone prodncers were in use for five years and are now for sale.

Stevens Institute, at Hoboken, N. J., have an Otto producer and gas engine, and also a Nash and a Mietz & Weiss gas engine, which are used for instruction purposes. These are direct connected.

*Gas Producer Plants for Baking.* The Cork Insulation Co., Jersey City, have two Smith producers generating gas to heat the ovens for baking cork insulating block. They have done considerable experimenting in the mixtures between pea and buckwheat in order to get a stable fire with free burning qualities, which will allow them to force the producers above their rated capacity.

The Hyatt Roller Bearing Co., Harrison, N. J., have 500 h. p. Westinghouse producers used for making gas for furnaces. They use bituminous coal and have the down and up draft system.

The Crucible Steel Works at Harrison, N. J., use two Hughes gas producers for open hearth steel process and they are reported very satisfactory.

*Defunct Gas Producer Power Plants.* Mr. C. E. Hertlein had no success with gas producers in his factory in the Bronx, New York City. They bought one plant in 1907 and in 1909 they bought another. Although the expert from the manufacturer tried to teach their steam engineer, it was unsuccessful. This was partly due to interruptions to service and partly due to the fact that live steam was required in their dye house. They found that exhaust steam from steam engines was just as good as boiler steam, and that with the steam engine running for making electricity their coal bill was about the same as when the gas producer plant was running. He now generates his power by steam engine.

The Cameron Machine Co., Brooklyn, N. Y., installed in 1907, a second-hand belted gasoline engine. The writer was informed that it was later changed to a gas engine for street gas and then was again altered to a gas engine for producer gas. They found it preferable to buy their electricity from the Edison Company.

The New Jersey Adamant Mfg. Co., Harrison, N. J., used a producer for three years and after changing the line of manufacturing sold the producer plant. They state that it worked satisfactorily.

The Harper Brick Co., Harrison, N. J., used a plant for two years but later sold it. They now use a steam engine for hoisting at the dock as the service is intermittent.

The Newark Spring Mattress Co., Newark, N. J., laugh at the suggestion of using gas producer power. They found it generally unreliable and said that all the experts in New Jersey couldn't make their plant run. This is the plant sold to Leiman Brothers machine shop, where it has operated with entire satisfaction for over three years. Apparently the success of a gas producer plant depends largely upon its environment, because here was a failure converted into an unqualified success, apparently by virtue of supervision.

The Public Service Corporation replaced the Newark Spring Mattress Co. with their electric service at a rate "much less than three cents." Mr. Odell, of the Mattress Co., stated, "I have nothing to remark except that we are perfectly satisfied with the arrangement."

The Adriance Machine Co., Brooklyn, N. Y., purchased a gas producer plant second-hand, but never unpacked it from the boxes, inasmuch as they completed satisfactory arrangements with the Edison Co.

The Manhattan Screw & Stamping Co., when inspected, had a gas producer plant with 75 kw. dynamo which is for sale. The firm retired from business.

As far as the writer can see, the failures of gas producer power plants are approximately 21 per cent of those which have been installed in New York City. Information from another source indicates that among the independent electric plants using steam in Manhattan Island, about 10 per cent have been shut down and replaced with Edison service.

It is a question as to whether the percentage of mortality for gas producer power plants is not low when we consider the comparatively recent development of internal combustion engines and gas producer as compared with the history of the development of steam.

The mortality rate for all the gas producer plants of which the writer has a record, indicates that 17 per cent of the number of these in New York and the Metropoiltan District have been discontinued. One of these cases was where the firm owning it retired from business.

The writer wishes to acknowledge his indebtedness to Messrs. Frank A. Pattison, Charles E. Pattison and D. D. Kimball, Consulting Engineers, whose generous and unselfish help made possible the collection of this information.

## DISCUSSION

John H. Norris: In connection with the National Meter Co.'s plant, data from which is given in Table 1, this plant is only charged once daily. The number of charges daily depends on the magazine of the producer. If a producer has a magazine which works exactly as a base burner stove, it can be charged once every ten or eleven hours, and if run twenty-four hours, it needs charging only twice a day.

To clear up a point in regard to the consumption for a 10-hr. and a 24-hr. load, the question of consumption on a stand-over load depends entirely on the operator. If he leaves too large an opening on his purge pipe, he will burn up more coal on the stand-over period than he would if the stop valve is closed down so as to just keep the fire in condition. The difference in ratio between the consumption on a 10 or 12-hr. load and a 24-hr. load is the difference in the amount of coal the operator burns up in the stand-over period. The ordinary consumption of a good producer is approximately 1.1 lb. per h. p.-hr. with coal running at 12,000 b. t. u. per lb.

In regard to the Auto Press Co's plant, I am interested in the data from that, as I laid out the plant, built and installed it. While they were operating they had practically no trouble at all, but they did get a poor man in the engine room and he practically wrecked the engine through inattention.

The plant of which Mr. Thurston is engineer has been in use longer than stated by Mr. Ripley. It is within my personal knowledge that that plant was shut up at half-past six at night and ran through till seven o'clock the next morning day after day for 365 days in the year, and only once in six years did the plant stop through the closed period. I do not know of a single power plant, unless it is an electric motor, that can be left to run itself that way.

This paper is restricted to the Metropolitan district. We know that putting a gas plant, particularly a producer gas plant, into operation in the Metropolitan district, is one of considerable difficulty, owing to the restrictions imposed by the civic officials and the Underwriters' Association. These

two elements prevent the use of the producer gas plant in what might be called the Metropolitan districts.

Horace G. H. Tarr: For the last few years R. D. Wood & Co., with which concern I am connected, has gone into the field of larger producers than are discussed in the paper. I had the pleasure of reading a paper before the American Water Works Association perhaps five years ago at the meeting in Toronto, when I advocated a greater economy in the installation and operation of small waterworks plants. At that time I cited very strongly a plant we had built at Poughkeepsie. Anyone familiar with that plant will remember that the pumping cost has been brought down about 70 per cent. The plant has been running now for eight or ten years, there has never been any accident, and the plant has been running as smoothly as possible.

In observing the pumping plants of the country, gas power plants, very closely in the last ten years, I have found that the greatest difficulty is in the operation of them. A gas power plant is not wholly fool-proof. The difficulty with most of the gas plants in this country is just as the author has said—the man who cleans up, scrubs the floors, works in the shop, and does the handy work generally, is put in charge of the gas plant. Many times trouble is experienced with plants simply because they are not operated properly. They are operated, in most cases, by mechanics and not by engineers.

Up to a certain size, a gas power plant is beyond any question just as reliable as an automobile if it is properly built and properly run.

In the larger installations of gas engines, 500 or 600 h. p., we cannot figure out the costs as closely as we would like to do. In our own plant, where we are melting 200 or 300 tons of metal a day, we have five 300 h. p. engines running the plant. What it costs to run the engines we do not know, for the reason we dry our molds and do everything of that character with gas. In one foundry, we run three engines of 300 h. p. and in another foundry we run two engines of 300 h. p. We cannot tell our fuel costs. We have been running these engines for eight or ten years, and we never had a single breakdown that was of any consequence. A cutting-off of power would be a serious thing, and would cost us a good deal of money.

In our work, we must have something that is reliable, and our experience has proven to our satisfaction the absolute reliability of the gas engine. As to the relative cost, when you come to put in a large gas engine installation, you will find it will cost you about $100 per h. p. A steam turbine installation will cost you a good deal less than half that. With several of our large installations, we are getting a horsepower-hour from one pound of coal, but the steam turbine, which costs half as much, will get down to less than 2 lb. of coal per h. p.-hr. These are the conditions in the gas producer business in the larger sizes. They do not apply to the small installations.

In a broad general way, Table 2 is exceedingly interesting, because it bears out almost exactly our own statistics. This remark applies to 500 h. p. installations.

It is no more fair to make a comparison of the gas plants of the present day with those of the past than to make a comparison between the automobiles now made with those of a few years ago. If a comparison is made of the plants that have been installed within the last two or three years, the characteristics of the plant can be taken and a correct opinion formed as to whether or not a small installation, 500 h. p. or below, should be a gas or steam plant.

There have been some failures in plants in the last four or five years. In one case of failure of a gas plant in Florida, I found it was due to the fact that they could not get any cold water. The water used for cooling was absolutely warm, above 70 or 80 deg. fahr. The water was drawn from a swamp, which was subjected to the rays of the sun, and serious difficulties were caused by it, showing that all conditions must be considered. If the latter is done, there is no question but that the gas plant is more, or quite as economical, as the steam plant.

E. Rathbun: I know, to some extent, the amount of patience required to get answers out of power plant owners, and the author deserves a great deal of credit for what he has accomplished.

We have a very interesting producer gas pumping station in Toledo where our factories are situated. All the city water goes through the plant; it is the filtering plant, and there are three 15,000,000 gal. direct-connected 2-stage Wood & Co. pumps, and also four 500 h. p. producers, the total capacity of the engines being about 2,000 h. p. There is practically no reservoir capacity. The plant has been in operation about five years and has never been without water. They have a spare unit, and keep the pumps running all the while, that is, the low service station. The water is lifted by the pumps and put through the filter plant—the pumps are in a pit 45 ft. deep below the river level—and the water then gravitates to the high pressure city service, which is steam-operated, and, everything considered, the producer plant pumps the water for exactly half what the steam-operated plant does.

In regard to the list of plants in Table 1, one of the plants in Bayonne, N. J., now shut down, is missing. The original plant there consisted of an 80 h. p. two-cylinder engine, and a 100 h. p. three-cylinder engine, which were operated by the Southern Cotton Oil Co. This company has other plants, to the extent of four or five, of the same make, so that they are familiar with the apparatus. It seems the shut-down in this case was a matter of faulty attendance entirely.

The plant at Bayonne was in the same category as all the other plants, and it should have been as good as the J. M. Horton Ice Cream Co. plant or the Mergenthaler Linotype Co. plant, or any of the other plants,—there is no reason why they should not all be the same. There was the same chance at Bayonne for securing the proper kind of labor, for securing the proper coal and everything else, but the plant was not successful. It was shut down, and probably the reason was not so much on account of the difficulties of running the plant, but because the costs of repairs were high.

For comparison, consider the J. M. Horton Ice Cream Co. plant, the Swift & Co. plant, and the plant at Bayonne. The J. M. Horton Co. report their repairs not higher than they should be. The Swift & Co. plant report their repairs higher than they should be, and the Bayonne plant is shut down, apparently largely on account of excessive repairs. The ratio of the costs of repairs on these

plants in five years is as follows: J. M. Horton Ice Cream Co., 1, Swift & Co., 3, and the Bayonne plant, 10.

On the basis of h. p. years, the cost of repairs of the J. M. Horton Co. plant was about 30 cents per h. p. per year; the Swift & Co. plant, $2 per h. p. per year from the time the plant had been in operation, which was excessive; and the plant in Bayonne, $4 per h. p. per year. I went over to the Bayonne plant once, and found the small engine was running with the exhaust wide open and the governor down on the engine. That was one reason why this plant shut down.

There are many interesting points in this paper. It has been brought out here that Mr. Ripley has made a point of dealing with the small plant, not particularly, possibly, but in his report he has called attention to the small plant. If you look at the plants which have been thrown out, it is always the smaller plants.

As you get into the larger plants it is true that it is very much more difficult to get reliable information. When we stop and try to figure out and go over our list of plants and get some accurate information about something, as close as we are in touch with our own plants, we find that there are very few plants in connection with which we can get absolutely reliable information. True, the Horton Ice Cream Co. is one of the plants which keep the most accurate information of any we have on our books. There are plants where they have wattmeters and get the coal consumption per kw.-hr. Perhaps in the same plant they are doing some pumping, however, and drawing gas for that, so their data is not reliable. Some plants do not keep any records whatever, and they are liable to guess at the coal consumption and give erroneous results.

One point which has not been brought out in this discussion is that the oldest producer is only sixteen years old; that sixteen years practically represents the total development of the art, and it is quite a short time. It must also be remembered that this paper covers only a very limited area, and it is a feature of the gas producer business, as of all others, that it shifts from one part of the country to the other. In 1906 and 1907, within an area of 200 miles of New York City, we put in about 3,000 h. p. within about two years, and yet during the past year we had just one inquiry from Connecticut. Connecticut, logically, should be the best producer gas district in the whole country—there is good coal available there, and everything tends to good operation.

As regards later developments, it happens in this district there are no raw water ice plants, and in the last year and a half we have put in six raw water ice plants. That is a new development, and is particularly adapted to producer gas power plants. We have put in about 1500 to 2000 h. p. in the last year and a half on raw water ice plants. The development of the raw water ice business is also directly connected with compressing. In many of the compressing plants, being direct-connected to the engine, they drop the speed 15 per cent and increase the compressor speed almost 300 per cent, so that while it is true that the business has not been so active in this district, still it has been more active in other districts. Table 1 is not, of course, absolutely up to date; there have been new installations since its compilation, probably, not less than 1,000 h. p. which is not included in the table.

WILLIAM T. PRICE: The gas producer plants which have been put in in the past three or four years, which Captain Tarr has referred to, are much superior to those put in originally. It seems that the very best location for the producer gas plant is the place where there is, first, a steady load; second, good coal; third, where pea coal can be obtained. A great many producer plants are started up and it is recommended that they operate on buckwheat coal. A great number of the plants mentioned in this paper are operating on pea coal, in fact, nearly all of them. The last requirement, and most important of all, is that a good man be placed in charge of the station.

Mr. Ripley referred to one plant, which was an utter failure in its first location which, when put in a new location, was a pronounced success. That is quite common with the internal combustion engine, and the problems that come with the internal combustion engine plant of any kind seem to be about 80 per cent operating problems.

A good many comparisons are drawn in the paper between the producer gas engine and the steam engine. A few comparisons with oil engines might be of interest.

The power gas engine plant is guaranteed to operate under certain fuel consumption per h. p.-hr., but in a great many cases the fuel consumption, taken over a long period, is considerably different from the guaranteed fuel consumption. That is because, as Captain Tarr pointed out, the economy depends principally on skill in operating. The oil engine, on the other hand, seems to show practically the same economy over long periods of operation that it does under test conditions.

The early oil engines which were put out, of course, were not as perfect as those which are being made today, and troubles were experienced. It seems, though, that the oil engine of the present, and of the future, compares very well with the gas engine of the present, but this difference exists: that the oil engine is a complete power plant in itself, whereas with the gas engine it is necessary to have certain fuel-making equipments. In the oil engine the fuel comes in a condition ready to use, but with the power gas engine the fuel must be prepared. Therefore, it seems true that, in the present and in the future, whatever troubles come with the producer plant should be eliminated in the oil engine plant. The relative fuel economy depends on location.

There are places where coal is very cheap and oil expensive, and in those locations the producer gas plant finds a good field and the oil engine is handicapped. All down this Atlantic seaboard, however, in the case of plants of 300 h. p. and downward, the difference in fuel consumption is very slight—sometimes it is in favor of the oil engine and sometimes in favor of the producer plant, and we may say that it is more generally in favor of the producer plant, showing that the fuel consumption with the producer plant is slightly less than in the case of the oil engine plant along the Atlantic seaboard. Of course, in the West and Southwest, coal is very expensive, and coal producers have never proven successful, so the oil engine finds a broad field there.

Another advantage of the oil engine plant over the producer gas engine plant is the saving in the space occupied. Mr. Ripley has given an intensely interesting study of data, and with close attention considerable profit should be derived from it.

# INDUSTRIAL SAFETY AND PRINCIPLES OF MANAGEMENT

BY W. P. BARBA, PHILADELPHIA, PA.

Member of the Society

THE matter of accident prevention has come to be considered as a point vital to the success of any business—through the operation of reasons, economic, humanitarian and sociological. Only a few years ago, say ten years, little was heard in this country of more than desultory efforts to minimize the waste of human effort through accidents. Now the slogan *Safety First* has been given widespread currency, and has lately been improved by coupling with it another, without which the first is really of little value, hence we now hear *Safety First—Safety Always*.

It requires no detailed presentation to make manifest the waste to the world of productive power through the suspension from their daily labor of men injured therein, of the consumption of materials without the corresponding production which normally would result therefrom—of the real suffering, both of the injured man and those dependent upon him, or of the investment laid aside and idle with every man injured. As part of a study of the principles of management (which should accompany the technical education of every man called to work amongst his fellows) much too little attention is given to the subject of methods of employing labor, both trained and untrained, and too little weight is laid upon the cost of training *any* new employee into the duties for which he is hired. Few realize that each man hired into a plant is the subject of investment for quite a time before he is sufficiently trained to the work he is to perform as to return a profit. It is probable that a study of the subject would produce a figure of $150.00 average of investment in each man before he becomes productive.

So when true principles of management are but little understood and rarely taught, it is customary to witness many discharges as corrective of offenses which are perhaps trivial at best, but which discharges in any case only act as correctives for the benefit of the employer with whom the discharged workman may next engage for employment. A better way, for instance, is to call up the man, convict him to his own satisfaction and yours, of the wrongdoing in question, and then and there apply the punishment which should correct the offense, using means which will inure to the benefit of the employee as well as the employer. This can be effected by lay-off or fine; discharge should be rare, and only for major offenses. Fines should be used most often in preference to either of the other more usual means. Fines should be laid with great care for the proper amount needed to effect the corrective, and a relatively small sum usually is sufficient. In no case should fines accrue to the benefit of the company, this having a very disturbing effect upon the value of the corrective, but fines in all cases, both for spoiled work and for discipline, should be converted into a fund for the benefit of the whole body of workers. Some mutual benefit plan, such as is now happily established in most up-to-date works, should receive the results of all fines. The result is then doubly beneficial, and has a balmy effect which removes all soreness and sense of *personal* injury from the transaction.

Referring again to the loss of investment from removal of trained men from production by discharge, let us also look at this loss through *physical* injury, and especially those arising from preventable causes. It is, of course, plain that the investment loss through injury can become a permanent loss of producing power, the loss of investment causing the employer to suffer, and the loss of producing power causing the injured man to suffer permanently, as well as through the physical pain he bears, meanwhile; his producing power and income reduced or gone, his expenses continue even on a reduced scale, his mental condition is much disturbed and he wonders what can be done, and so the rapid but all too slow growth of the safety movement, the liability and compensation laws, the preventive measures, but most powerful of all, and as yet but little developed, the education of every person engaged or even interested in industry, to the end that all preventives be used both *without* and *within* the person of the operator subject to injury.

Figures compiled during a term of years point most strongly to the lack of proper education as the prime cause of injury—loss of productive power, and all the attendants of this condition. Hence, industrial safety and sound principles of management are without doubt most closely bound together, and cannot with success be considered apart. Commissioner John Price Jackson, of the Department of Labor and Industry of Pennsylvania, has shown in dollars and cents just what the large number of accidents that are occurring in the industries of the State, are costing the workers. He has not figured what they cost the employers.

During 1914 accidents cost employers in a score or more of the larger industries in Pennsylvania the sum of $1,048,-503.96, which total is computed on the daily wage. There were 38,126 men thrown out of work and each of these men lost on the average $27.50. The accidents from which Commissioner Jackson has computed the figures do not include those reported to the State Department of Mines or the Public Service Commission. The report shows that about one man in every 28 lost time because of accidents, as there were 1,086,508 employees in the industries from which statistics were gathered. The average daily wage was $2.45 and the total number of working days lost was 426,824.

This brief report gives one an idea of the extent to which accident prevention may go, the aggregate for this State only being so large as to appall one, and still does not include mining risks that are notoriously great. Indeed, most of the opposition which was disclosed in an organized way to the enactment of a workmen's compensation act has been from the smaller operators of mines, whose whole capital could be annihilated by the liabilities arising from one accident on a small property.

From the operation of these causes, motives and products alone, there has within the last eight years, come into being a general safety movement, looking more toward the possibilities of prevention than ever before. Out of all the upward striving of humanity toward better things and better conditions comes a new principle: namely, that a trade should bear the charges and costs of its casualties, and from

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this, the employers' liability and workmen's compensation movements have gained much force. Rarely has there come before the public a movement involving so-called capital and labor, but in reality employer and employed, which has met with such complete support from both sides. But there *are* no "sides"—the interests of *all* employed in the world's productive work are entirely identical. To enlarge upon this thought, for it is one of the links attached to the title of this paper, these two, together with their many links, are inseparable—in practical everyday work, just like a graphically expressed formula in organic chemistry.

It will have been noticed from these prefatory remarks that this connection is quite clear. One who is charged by his owners with operating a large manufacturing plant has as his first practical concern, the securing and retaining, as well as maintaining in good efficient condition, a well satisfied body of workmen, contented, well paid, and their physical condition well in hand.

After this the managing executive may take up his financing, his raw materials, manufacturing methods, selling organization, etc., but no manufacturer can possibly succeed without this satisfied body of operating workmen—fellow employees as just outlined—to secure and maintain this condition is a prerequisite to any further success.

The economic as well as the social side of this problem must be just as carefully looked after, now that Pennsylvania has a workmen's compensation act, the twenty-fourth in the United States, which country followed quite a long way behind both Germany and England. No longer will industrial safety be thought a fad, no longer will the courts be filled with cases crying for just relief, no more will the cheap lawyer haunt the hospitals to prey vulture-like upon the unfortunate. Each trade is to bear its share of the cost of its casualties, and the ultimate consumer will pay the bill. All this is exactly as it should be, the only danger lying in the chance, a real danger too, of the whole game being absorbed into some form of political spoils, which God forbid.

Much is being said and printed about foreign trade, foreign competition, foreign methods, and many have objected that the securing of this foreign trade in normal times was difficult, due to the difference in labor conditions, rates of pay, etc. It is very interesting to note that in 1885, Germany established compensation measures, followed by England in 1891, so that our trade abroad is not menaced by the adoption here of these plans for workmen's compensation. On the contrary, we have lagged so far behind these stiff competitors, in these particular matters, as to cause unfavorable criticism of us by those who know.

Now when such compensation acts are generally in force, each employer will be placed automatically on piece work to make his plant *safe;* and the penalty for failure to achieve safety of equipment will be very great. There are, however, other features in the case: present and proposed laws provide greater compensation for a man with a family than a lone bachelor without dependents, some laws providing compensation for the grandfather of a man injured, when dependent. The natural result will be to select for employment men who offer the lowest risk, both as to compensation penalties and as to physical condition of the applicant, which condition exactly reflects chances of injury, and consequently, the rate of risk. The compulsory insurance laws of Great Britain, placed in operation in 1912, immediately resulted in selection of employees whose rate of risk was the lowest, and thousands of perfectly good workpeople were turned adrift for this reason.

This is one of the consequential results our legislators and agitators should consider most carefully. There will inevitably result, a careful selection of the best insurance risks, and defectives of all kinds will find it most difficult to obtain and retain employment. A defective in this sense may be a man physically unfit, incipient hernia, a tendency to joint dislocation, etc. He may be defective in the sense that he just cannot keep out of trouble, and this kind of a man soon cannot keep himself in a job. He will be *selected* to be always out of a job, until he learns to *think* enough to keep himself from unnecessary injury. Study of the figures showing frequency of accident to the individual no matter where working, inevitably searches out such men, and then the employer must move the man, either to another job or else *out,* both ways meaning a loss of investment, production and earning power. Again education, both of the man and his employer, most necessarily his immediate foreman, is needed and just how best to supply the lack is a task worthy the best mind in your employ.

The works with which the author is intimately associated, has for years made a careful physical examination of each man offering for employment, having in mind his condition with reference to health, present and potential, his record as to previous injuries and their results, his eyesight, hearing and whatever condition will affect his value both as an individual and as affecting his fellow workmen.

At one works there were offered for employment, practically hired, then turned over to the physicians for this examination 2,569 men during the year 1913; of these 391, or 20 per cent were rejected for various reasons. Of these 391 rejected, 285, or 75 per cent, were rejected for venereal diseases and consequences, it being deemed most unsafe to turn loose a man possibly syphilitic amongst presumably clean fellow workers. Of course, a man may pass inspection upon employment, and then find his health go down. He may become the subject of venereal disorder, or some other form of communicable disease. The answer for this is the growing need for periodical examination of each individual worker, and his elimination when his risk becomes too great. This periodical examination of employees has been undertaken to much too small an extent, and needs attention and developing. The benefits are numerous, the first and chief being the aid and assistance to full recovery, and checking in advance of disease which a man unconsciously fights off until he drops—mastered. Beaten by exposure to a blizzard or heavy storm when in a reduced condition, many a good man is lost, who, by a regular, even though cursory, examination might have been saved through timely catching, checking and conquering, through advice and aid, of an ailment creeping up on a man almost without his knowledge of anything going wrong. In this connection arises the demand, a just one, for some form of insurance, preferably mutual, and upon a sliding scale, according to the risk offered by each man. This is but one of the many problems each executive is going to face in the future handling of employees' matters.

When a man is hired, he should be taken to his foreman for careful instruction in his duties, its dangers and their safeguards pointed out, and every effort made to prevent

the new employee from becoming worse than a normal risk. As one concrete illustration of this, in a certain large works much fuel oil is used for heating purposes, and a comprehensive system of storage and distribution is installed. Leakage is impossible to entirely prevent, and numerous explosions and small fires have occurred. It is necessary at times to descend into the pits in which the apparatus is placed, and the explosive fumes of oil and air are frequently present; steam pipes (not air—because of the danger of air) are rigged in all such places and at stated intervals the steam is sent through these chambers entirely and safely displacing all noxious gases.

Again, the burners for fuel oil are merely a combination of jets and valves—some of the jets embodying the injector principle. Each man who is called upon to work with this apparatus is taken into the bureau of Safety First by his foreman, and with the safety engineer (a high priced executive) is taken through a course in his particular oil burning apparatus. The collected unit is there, it is disassembled and reassembled by the man, and a partly cut-out section is shown, so that all the functions of the system are fully understood by the workman. Since the introduction of this system of instruction, the number of burns and fires from ignorant handling has been very much reduced. It is impossible, however, entirely to eliminate the accidents from careless handling. Here, as elsewhere, the adage "Familiarity breeds contempt" is true, and it would be easy to multiply concrete illustrations of this statement.

In 1907, in a nearby large works, the safety movement was given a real start, by the appointment of a safety officer, whose whole duty was to report hazardous conditions of plant and equipment and see that the conditions were corrected. It has lately been more generally recognized as the function of the factory inspector of the State to keep every manufacturing establishment in a safe condition, so far as equipment, etc., is concerned. The present incumbent in Pennsylvania, Dr. John Price Jackson, has given real value to this function for the first time, but even he, up-to-date and progressive as he is, recognizes that the correct way is to make each factory safe automatically by having liability laws which properly penalize the lax employers.

The attempt of 1907 to effect safety of equipment by the appointment of a safety officer and his staff, in the works mentioned, was soon superseded by a plan to make the worker himself feel his share of the responsibility, and a committee of 70 men was chosen from among the employees, there being upward of 5,000 employees. These men were always on duty while regularly working and seven of them were chosen each week and with the safety engineer gave up a whole day in the company's time and pay to actual examination of conditions of plant and equipment. Their recommendations were given priority by heads of departments and the works were soon found in such good physical shape that the committees had little or nothing more to report.

The number of accidents was, of course, reduced, but not to a point which was thought commensurate with the efforts put forth. During all of this time (five years) careful study and analysis was given the daily accident reports, with the result that they soon segregated into three groups:

1. Hazards of occupation
2. Hazards due to faulty equipment
3. Hazards due to personal carelessness and disregard of safety appliances.

These regularly occurred in almost unchanging proportions, even though the sum total went steadily downward:

The first class—Hazards of occupation, 24 per cent.

The second—Faulty equipment, 3 per cent.

The third—Carelessness and neglect, 73 per cent.

This large proportion, 73 per cent, is purely a result of the operation of the personal equation, and, at once suggested itself as the point of attack.

To meet this a total change of programme was inaugurated. The plant was divided into seventeen distinct units or geographical districts and a committee of three was appointed in each for a term of two months. A datum line for each district was established from history which showed the frequency of accidents in each district. The figures were worked out in units per one hundred men employed for the period of two months, thus affording easy comparison.

The task set was for each district to equal or beat its previous record. No district was set against another, its record being wholly within itself. This is a vital point. Each sixty days' record is merged into the previous total and thus a new record automatically set. For a committee which equalled or beat its district record during the committee's sixty-day term, there was established for each man a cash prize of a ten dollar gold piece, or $30.00 for each winning district each sixty days (incidentally the amount thus paid during the year 1914 was $3,200.00, and no sum was ever more cheerfully paid out). In addition, the committee which made the greatest improvement upon its own record was, each period, granted a double prize, or $20.00 to each of the three men.

The experience of the first year was that out of the seventeen districts there were paid prizes all the way from four up to sixteen districts, the four being midway in the year, and the treatment applied by the management when this low score occurred, brough the score right up, so that at the last period fourteen sets of prizes were paid. The personnel of these committees is changed each period so that the experience gained is accumulated by a large number of men.

The treatment in this case was simply for the general manager to talk to the assembly of the men later referred to, and point out, from knowledge of the accidents occurring during the period when low scores were made, how greater vigilance, less laxness, more attention to the men seen to take hazards carelessly, would result in better scores, more gold pieces, less suffering, to risk of which each of the whole number of employees is subject, whenever vigilance in these particulars is relaxed.

There is also a collateral advantage which is a large part of the value of this new scheme. The management hires a large and convenient hall for a meeting place, provides cigars and light refreshments, invites all the men the hall will contain (about 400) and makes a public occasion of the presenting of the prizes. A free discussion of methods and experience is had, and from 8 o'clock to 9:30 an evening is spent which is most profitable in every way. Stimulation is given the safety movement, the managers are all there, and a great feeling of the community of interest of all concerned is engendered. The spirit of full coöperation is established and fostered, a better and closer acquaintance is had on all sides, and the whole effect is most beneficial.

The net result in figures is curious and interesting. By an accident is meant the state requirement or definition—that a man is away from his work more than two days. The number of accidents during the year just closed was reduced by 59 per cent, the three above classes being represented by 26.8 per cent, 2.23 per cent and 71 per cent, clearly showing that there is still more work to be done in fully bringing home to the individual his personal share in the responsibility for his injury.

This responsibility is going to be more closely brought home under compensation acts, since it will mean the elimination of men who are thus injured through their own fault too frequently; these men will be compelled to seek other employment. It then becomes a nice point of judgment for the management to determine whether its investment in such a man, i. e., his trained capacity for his work, is a sufficient offset against his increased risk, due to his propensity for acquiring injuries to an undue degree. Some of the compensation laws refuse a man any payment if it be shown that he was injured by *his own act* for the purpose of going on the benefit list. This provision and the one denying benefit for the first *fourteen days* are about the only safeguards the employer has against unjust claims for payments.

Reverting to the system suggested of avoiding discharge losses through conviction and fines, the proper channel for restoring fines upon delinquents to circulation through the whole mass of employees is—the recognized need of caring in some way for the reliable employees unavoidably injured slightly, and returning to work within the 14 days exemption period provided by recent compensation laws.

A fund could be provided, augmented by the company, especially so in the case of larger employers, this fund to be administered by a mixed board of employees, and a small measure of financial relief afforded the unfortunates who recover within 14 days. This period, designed by framers of the acts to prevent malingering, does not altogether effect this, and meanwhile works a real hardship on many worthy men whose needs are such that the uncompensated loss of *any* days becomes a matter of concern.

If ever there was a subject fit for Federal instead of State legislation, it is this one of liability and compensation. Fifty-eight States working each alone may produce such wide diversity of legislation as really to put neighboring States into competition for both manufacturers and for workmen. When John P. Neill was Federal Commissioner of Labor he worked assiduously to secure uniform State legislation on this subject because there were statutory difficulties in the way of a Federal act. This leaves it up to the several States where too often a subject of this magnitude is taken up by untrained and uninformed legislators who can, quite possibly, be swept into ill-considered action by a wave of hysterical outcry from the newspapers, professional labor leaders, and publicists who treat a situation academically and without close knowledge of the problem.

With especial reference to the Pennsylvania law just enacted, it is fine to recall how this law was prepared. Begun under Governor Tener by a board of broad expert business men, thrown out by the legislature of 1913, brought up again by a Governor fearless of criticism, worked out modernly upon the basis of the original commission's draft, the Pennsylvania law is, generally speaking, satisfactory to all groups, and there is in it opportunity to coöperate fully, to protect those dependent upon their labor for daily bread, automatic incentive to clean, healthful surroundings, care in safeguarding equipment, and all concerned are compelled to do their utmost to achieve the blessed result desired.

Any employer, or rather fellow employee, who shall disregard the plain common sense demands for a legitimate, well considered scheme for automatic compensation for every injury not wilfully incurred, is not alive to his business, to his duties, to his men or to his stockholders, nor to his duties to the progress of humanity at large.

It is the speaker's firm conviction that the so-called *industrial unrest* is wholly preventable, is due chiefly to lack of understanding of the problem—lack of patient working in full coöperation with all concerned, and the result of following sound principles with policies based thereon is certain to prevent unrest such as has been all too frequent from just such causes.

The years in the immediate future will be largely occupied with the care and handling of just such problems as are here presented, and if anything said here gives a line to take hold of and follow, the author will be more than glad of the opportunity to discuss a matter so large as that of the subject presented. In pointing out the dangers of haste in enacting such legislation, all right thinking people are urged to work for the passage of such laws as will compel the lax, careless, or unwilling employers to secure the coöperation toward safety of workers whose livelihood, and lives, are in the hands of those who pay wages, and as before mentioned should find it a cheerful duty to work toward the securing through coöperative effort, of the maximum of safety, comfort and happiness among all grades of employees. Only thus will the work of the world be furthered. Only thus will there be removed from among us strife, discord, class distinction, unions and non-union, and there will surely come into industrial life, the big rewards which result from careful thought along lines which go to promote full coöperation amongst those called to do the work of the world.

# SAN FRANCISCO MEETING

*THE five papers presented at the two sessions of the September meeting of the Society held at San Francisco, September 16 and 17, in connection with the Panama-Pacific International Exposition and the International Engineering Congress, were published in the October and November issues of The Journal. In this issue is published the Discussion that followed the presentation of the papers. That upon the paper by G. L. Bayley, is of particular interest for its application to the varied construction problems at the Exposition, and that upon the paper by W. H. Adams, in view of the development of the Diesel engine on the Pacific Coast.*

## DISCUSSION OF PAPERS AT SAN FRANCISCO MEETING

### PAPER BY G. L. BAYLEY

G. L. Bayley, in presenting his paper on the Engineering Features of the Panama-Pacific International Exposition, dwelt upon features of interest supplementing the text of his paper, as given in the following account:

Mr. Bayley, referring to the planning of construction methods and preparing estimates and load curves for the Panama-Pacific International Exposition, said they naturally wanted to be guided by data relative to previous expositions and had searches made for such data, even in the Congressional Library. To their astonishment, little real information was available. Such an important item as the maximum load at the St. Louis Exposition was finally found in Engineering (London). The load was 13,500 kw. All the various reports of that exposition gave full descriptions of the great power load, how many thousand horse power was being utilized, etc., but the maximum load and diversity factor, or any other elements which would have been a guide in their case, were not available. It is impossible from any reports to find the amount of water used at previous expositions; any records, where they exist, are not available.

When they started in to build the Panama-Pacific International Exposition, Mr. Bayley said that if they had only known half as much as they know now they could have saved many thousands of dollars. Now that they have collected a great deal of information, much of which is of real value, they intend putting it on file in the Engineering Society's Library in New York so that it will be available in the future.

The area occupied by the main group of the Exposition palaces, which includes eight large buildings, was about 12 ft. under water when they started operations, Mr. Bayley said. So at the very inception of the work, they had a problem of considerable magnitude. The filling in was performed by the aid of suction dredgers, and in that connection they followed out a procedure which he did not think was unusual, although it has attracted some attention, that is, getting rid of the soft bottom by displacement of the heavier material. The discharge pipes were so located that the heavy sand kept forcing the ooze and mud ahead of it and out through the sluice gates. Occasionally, in order to stir up that material, they would run the dredgers without pumping any sand. The result has been a very solid compact fill, which, however, has been settling regularly as was expected. The large buildings were all placed on piling, and the amount of piling is somewhat tremendous. He conveyed some idea by saying that if the piles were all stood on end, they would form a column 125 miles long, and if one stops to consider the cost of driving 125 miles of piles, one realizes the initial work on hand.

Before starting the work of pile-driving, Mr. Bayley said a number of experiments were made to find out the load which would be permissible, and these experiments proved to be exceedingly valuable, not only from an engineering point of view in determining the amount of load that a pile would stand, but as to the exact length of cut-off of the various piles, so that when a contractor was called in to take a contract for piling, he knew exactly, within 6 inches almost, the length of piles over the area. In that way they obtained close bids, because the contractor knew that he could use piles of 35 or 40 ft. and so on, and he would not have a lot of other lengths cut off which could not be used.

They found, in driving the test piling, that the fill itself imposed a considerable load on the piles. One can realize that from the suction of the fill on the pile, and the fact that the fill was settling. A portion of the fill was over an existing sand bank, under which lay a stratum of clay. Following the standard procedure, they would have driven into that clay and probably have used a 40 ft. pile. They found by experiment that they could drive into about 12 ft. of sand but not puncture through it, and get practically the same bearing value with those piles. The result was that they used 12 ft. piles instead of 40 ft. If that were converted into thousands of dollars it would be a considerable amount, all of which indicates the advantage of proceeding with exact knowledge of the conditions as they exist, and which can only be determined by experiment; although they spent probably $6,000 in getting this information, it was well worth many times that amount.

Mr. Bayley then referred to the question of structural design of the Exposition, most of the structures being timber ones. In the last fifteen or twenty years very little advancement had been made in frame structures, because steel had supplanted the use of timber very largely, and frame structures have been mostly used only by sawmills and similar activities. In the instance of this Exposition, wood was by far the cheaper material to use, and in addition, could be gotten very readily, whereas there was an element of time in getting deliveries of steel. That knowledge which had been secured to engineering by the steel practice has been applied with rare intelligence to the design of the wooden structures of the Exposition. In the Machinery Building, for instance, there is some very interesting frame work. Shear pins are used effectively, and the enormous roof structure really seems to be very light.

Some very valuable data was secured by testing out full sized joints, Mr. Bayley said, and, strange as it may seem, with a shear pin made of a certain Hawaiian wood, a greater

strength was deleveloped in the joints than if the pin were made of solid steel. A technical paper has been written on this particular subject, and those who may be confronted with a problem in timber design might well consult this. With the exception of the Tower of Jewels and the Palace of Fine Arts, the buildings are all timber structures, and all are carried on pile foundations, except a certain one or two, which are on spread structures.

The Tower of Jewels is a most interesting example of engineering. This was built up as a pyramid, and as originally designed the tower was to contain the administration office and presented a very serious problem of construction. That idea was abandoned, however, and the weight of the steel was reduced by half; in other words, the tower was framed up for the usual load of floors, after the same type of construction that is used in office buildings. By adopting the pyramid form, and furring on the various platforms of timber, the cost of construction of the tower was considerably reduced.

Mr. Bayley pointed out that the Exposition is more or less of a dome city. Dome construction is somewhat unusual, and many interesting problems were solved in connection with the various domes that are at the Exposition. Doubtless, the most interesting dome is that of the Palace of Horticulture, which has the largest spherical dome in the world. It is 152 ft. in diameter and has a height of 185 ft. To show the difference in results that may be obtained by starting on different suppositions, one engineer designed that dome as a 3 in. arch; the depth of the ribs was 6 ft., and the angles used were six by six. Another engineer designed it as a through dome, with ribs 4 ft. deep, and angles four by four. Doubtless, the former engineer's calculations checked out all right, but by adopting the latter's figures, the dome was built with about half the amount of steel and is a perfectly rigid and stable structure.

The method of erecting this dome was to take two ribs, form them together on the ground and then hoist them. A gin pole was used in the centre to carry the ring and hold it up while a third rib was put in, when of course, the structure was comparatively stable. After that, one rib was put in at a time until the dome was completed. The methods used for putting up these domes were very interesting. Apparently, no two contractors agreed as to the best method, and many ingenious means were employed.

The method of dome framing was rather original, and the framing of the great half domes on the west side of the Palaces of Food Products and Education were very interesting examples. The Palace of Fine Arts is a building which is semicircular in plan, and, of course, had to be free from all columns; for that purpose the three-hinge steel arch construction was used.

At the start, Mr. Bayley said, rules were made governing all structural work; in these rules the allowable load stresses and other designing data were established, with the result that the designs were consistent throughout. In a work of this magnitude, it seemed very essential that each man's work should agree with the work done by every one else. In other words, consistency on the part of each individual designing engineer, in such assumptions as factors of safety and unit stresses was desirable. Not only did the Exposition have a large corps of designers of its own, but, owing to the press of work and the shortness of time, some outside engineers were employed and these received the same set of rules to govern their designs.

Regarding the sewer system, Mr. Bayley said there were no especially difficult problems there, except that they had to lay the sewers bearing in mind that the ground was settling, so that wherever they had connections from buildings, they had to be flexible connections, which called for a special design. At the State and Foreign sites, owing to the flat grade, and the Exposition grade being only a few feet above high water, it was necessary to put in some pumps, drain the sewage towards one central point and pump it to the Bay.

Under the head of transportation, Mr. Bayley said their greatest problem was that of handling lumber. It was really quite an inspiring sight there at times to see six or eight vessels all piling lumber down, but the large volume of work was well cared for by the simple method of using lumber trucks and horses.

Possibly no problem in connection with an exposition, Mr. Bayley said, is more serious than that of carrying on building construction and trying to maintain roads at the same time, and especially as so much work is usually done during the wet season. Of course, at San Francisco they worked all the year and very few days were lost. Plank roads were used throughout to great advantage and while probably $40,000 or more was spent for those planks, the expenditure was well justified, because they could very rapidly change a road in order to get material in for the various buildings.

The plank roads were further useful at the time they came to build the permanent roads. In constructing the permanent roads, they found a very satisfactory method to be to build half the road and pave it, in the meantime maintaining traffic over the other half by means of planks. Then as soon as the half was paved, they would move the planks onto the paved half and switch the traffic onto the planked side and build the other half of the permanent road.

Rigid traffic rules were necessary, Mr. Bayley said. Teams were obliged to come in at a certain point and go out at a certain point; otherwise there would have been a hopeless jumble. Those who have not seen the building of an exposition, he said, can hardly conceive the amount of pre-exposition traffic, particularly just before the opening day, when teams are coming in with exhibits. Exhibitors are habitually late, and they all come in at the last minute and work all day long and into the night making deliveries, and, unless a good scheme has been well thought out to cope with the situation, confusion is liable to reign.

The Exposition undertook to deliver exhibits directly on the exhibit space. This was quite a departure in exposition traffic, but one which has been very satisfactory to exhibitors. In previous instances, the railroad terminated at some point in the Expositon grounds and then the exhibitor had to make arrangements with some local concern to get his exhibits moved in. Here they made a terminal rate so that an exhibitor, say, in Philadelphia, could get from the Pennsylvania Railroad the exact cost of transporting his exhibit and delivering it right to his space in the building it was to occupy.

As they undertook that obligation, Mr. Bayley said it was essential that they make some arrangement to take care of the situation. They ran spur tracks into all the buildings, with unloading platforms and then made use of

the transveyor, which is a small truck with a mechanical arrangement for use in connection with special platforms, and with that they handled the situation without any congestion. In the same connection they had a number of storage battery industrial trucks and at times these were used to haul the transveyors. In the Machinery Building were installed overhead cranes.

Attention may be called to the excellent manner in which visitors are transported about the grounds. Those who were at St. Louis will probably remember that they had the automobile busses, but they were very hard to enter and alight from. Here they had the so-called Fadjl train.

In the matter of fire protection, Mr. Bayley claimed that no exposition had a fire protection comparable with that installed at this one, and it may safely be said that few communities enjoy an equal security against fire. In addition to the high pressure distribution mains, there was installed a sprinkling system in all of the eight buildings of the main group. In the Machinery Building it was not thought that the sprinkler system would be very effective, owing to the great height of the roof.

The next matter of great importance was that of water supply. In this connection, it was found that the local water company could not supply them with water, and they were confronted with the problem of supplying about two million gallons a day.

Few expositions have ever had an adequate supply of gas. He thought it was safe to say this was the first Exposition that had gas at every portion of the grounds and that in adequate supply. Gas had been a great factor in many respects. Almost all of the cooking in the Exposition grounds was done by gas. In order to cover a square mile of area at a reasonable cost, the high pressure gas system was used. Gas is distributed at a pressure of about 80 lb., and the pressure is reduced by means of governors at the various points of use.

Regarding the gas lighting of the streets, in the State and Foreign sites, there was an installation of over 250 high pressure gas lamps, which he thought was easily the largest in the United States and also one of a very few. Here can be seen the great possibilities in high pressure gas lighting. The gas mains were all welded by means of the oxy-acetylene process.

### PAPER BY G. W. DICKIE

G. W. Dickie, in presenting his paper upon Mechanical Engineering at the Panama-Pacific International Exposition, said that in some respects this Panama-Pacific International Exposition differed from all the other international expositions that have been held, in that it represented a changing condition in mechanics. There were no steam engines at this Exposition with the exception, perhaps, of one or two—none of them in operation, and none of any size worthy to be considered as monumental. There was one 500 h. p. double cylinder sawmill engine, which was a very plain piece of work; steam was carried probably seven-eighths of the stroke. But it was worthy of mention as the sawmill engine is built to consume all the power derived from burning all the sawdust the mill makes, and if it cannot do that it is not a success. In order to do that it must not be economical in the use of steam.

## DISCUSSION

A. Stucki said that, coming from Pittsburgh, it struck him very forcibly to hear that wood was mostly used in the construction of these buildings. Ordinarily it is said: "Wood is not in order any more. Steel is cheaper and stronger." But here it was found that it is more economical to use wood instead of steel, and he understood that Mr. Bayley had made a very thorough study of it, applying engineering principles. But what struck him most of all, was the foresight exhibited in not only following financial views in getting the buildings installed cheaply, but in protecting them by a sprinkler system for fire protection, such as has not been used before in such magnitude.

H. G. Reist asked whether the same thing would hold today with the Panama Canal opened; that is, whether a large part of the difference between the use of steel and timber was not due to the transportation of steel.

A Member asked Mr. Bayley how they determined in the beginning the approximate floor space required for the different exhibits.

John R. Freeman, referring to the use of wood rather than steel in the framework of the Exposition, called attention to the duty of the interior architect. Even so good an authority as Newhouse has said that we have to compliment engineers for knowing how to make the interior of a building. He had had the pleasure of handling a great many of these expositions, all the way from that of Paris of 26 years ago to those in Chicago and St. Louis, Portland and others, and he had never yet been in any large building for exposition purposes of a temporary character where the framework was arranged so that it was fancy and beautiful until he came to this Expositon here. He thought a compliment should be handed to the men who designed the interiors of those buildings and worked those trusses out of lumber at $13 a thousand and made them beautiful.

W. C. Lindemann asked if in the consideration of the salvage on the Fair buildings, a definite figure was arrived at, and if so, how it was calculated. In figuring the cost of work, of course, the salvage value has a considerable effect on what the ultimate work is going to be.

A Member asked Mr. Bayley if they have anticipated any system or method by which the salvage on the Exposition installation may be decided on when the Exposition is closed.

Selby Haar, referring to the estimate that was made of the electric load as a load factor of thirty per cent, asked whether that estimate came pretty close to what was actually right.

H. G. Reist called attention to the beauty of these made-to-order cities at the various World's Fair Expositions. This one, is particularly beautiful, both in the individual buildings and in the grouping of the buildings, and it would seem strange that in the building of these temporary cities such beautiful results can be achieved, but in building permanent cites they are built very much haphazard. He felt that it is largely up to the engineering profession to try to make a change so that our permanent cities will be as beautiful as our temporary ones.

G. W. DICKIE, referring to the lack of data in connection with exposition building which was a great handicap to them, said he was sorry that Mr. Bayley did not discover the stupendous report of James Burge, as British Commissioner at the Chicago Exposition, in which there is an immense amount of information. The buildings are all tabulated there as to load and the foundations and also cost of building per cubic yard and foot and square foot of floor, etc.—a very interesting gathering of data, that he thought had been used very largely in expositions, especially in Europe.

MR. BAYLEY, in answer to Mr. Stucki and Mr. Reist, said it was largely a question of settling the height of the buildings when the buildings were being designed. About two and a half to three years before the Exposition opened, there were some grave doubts whether the Panama Canal would be opened at all; in fact some were afraid the Exposition would be completed before the Canal, and at the time there were no assurances whatever that they could get required delivery of steel and also the expense was very much higher. Of course, here they had the timber, and the most splendid timber, delivered for about $13 a thousand and steel didn't have much show. It is largely a matter of cost, and has to be figured both ways—whether the steel can be gotten for a less price. He was very sure that wood would be the cheapest there in any event.

Replying to the question concerning floor space required, Mr. Bayley said exposition building goes by habit, so far as he could ascertain, and he tried to find out how much space was assigned at previous expositions for a certain classification. They had to depend very largely upon the recommendation of the division of exhibits; in fact, that division really specified the amount of space that would be set aside, and it was their thought to divide products.

In reply to the question concerning determination of salvage, Mr. Bayley stated that the salvage value is just a matter of opinion. He believed that in the Western market, they could get rid of the lumber. One would be astonished to know how much second-hand lumber is used on the West coast. The mine people use it for timber work, and it is used for bridges, all sorts of temporary purposes and a great deal of permanent work. Of course, in the question of the selection of timber the salvage practically was not so important. In other kinds of salvage they knew pretty well. For instance, waterproof wire has a good salvage value because the insulation can be burned off readily and there is the copper. With a conduit, however, there is no salvage value and they wanted the cheapest possible initial cost.

In reply to the further question concerning salvage when the Exposition is closed, Mr. Bayley said he was then writing the contract for the sale of the Exposition, as a set of specifications. They would solicit bids to buy the Exposition outright and undertake the salvage, as they did not care to do the salvage themselves. They were satisfied with having built and operated the Exposition, and want to sell it for a lump sum. He said there was a very large amount that was not included, as they were singularly fortunate in getting a very large amount of material on a rental basis, which in fact, effected a very large saving, aggregating almost a million dollars.

In answer to the question of Mr. Haar, Mr. Bayley replied that the load factor of thirty per cent. was so close that it might be said they had advance information; it was a little over 29 per cent.

In reply to the question raised as to why we can build something temporary and make it a unified whole and something of beauty, whereas we fall down in such a remarkable manner when we start to build permanently, Mr. Bayley said he thought the answer was not difficult to see, and it is that they had concentrated control. Take, for instance, the case that so often results in developing civic centers and other monumental groups; one regime will take hold and they will work out a scheme, somebody else will come along a little later, and then another architect will probably succeed him. He referred to a wonderful instance of that in New York in one of the cathedrals; each one of the architects had his own individual ideas. Here, at the Exposition, there is no one man who dominated the architectural situation, but there was an architectural commission. The idea of the block plan made it essential that they all work together. There are different types of architecture, but there is no conflict, because one cannot see three courts at once. One may go around that whole area, the whole length of those buildings, and it was all the work of one man. The result is continuity and harmony. Each man would express his individuality, which, he thought, was really the success of the Exposition; it was due to the fact that they started with a scheme which necessitated harmony; that is, they could not very well go astray, so long as it was decided to have one man, or one element.

PAPERS BY W. H. ADAMS AND A. H. GOLDINGHAM

## DISCUSSION

H. R. SETZ called attention to two points of especial interest to all; one is that mentioned in the last paragraph of Mr. Adams' paper, par. 65:

> The item of life of the Diesel engine is open for discussion, but no one can yet say definitely what the life of the Diesel engine, properly taken care of, is going to be, as none of our successful plants have been in operation long enough to give the answer.

In order to get an answer, we will have to look to Europe, because it is in Europe where the Diesel engine had its conception, and where it has been perfected to the highest stage of completion. The history of the Diesel engine in Europe has proven that all the parts which are subject to wear, at least in a well-designed engine, can be replaced at a cost of about 35 to 40 per cent. of the initial cost of the engine. These parts include pistons and cylinder liners, for instance, valves, bushings, and all those parts that are subjected to natural wear of the engine. It, of course, does not include any breakages like broken crank shafts. But such a thing doesn't occur in a good Diesel engine. European practice has brought out that these parts will stand up easily from eight to ten years.

Mr. Setz was in 1901 connected with Dr. Diesel, and was then testing a two-cylinder engine, which some of the engineers that were in Europe about two years ago undoubtedly saw. That engine is operating a match factory in Bavaria now, and at that time, had been in operation for twelve years. The pistons and one cylinder liner have been replaced in that engine; all the other parts are practically the same parts as the original engine contained, and that after twelve years' operation.

In one of the two papers that were presented Mr. Setz noticed that the depreciation is figured at ten per cent. In view of these experiences he thought ten per cent. was far too high to figure. It is doing the Diesel engine an injustice if ten per cent is figured, because in less than eight years the whole Diesel engine will have depreciated from its original purchase value to nothing. He would recommend a depreciation of about four per cent. in trying to arrive at the cost of the power produced in a Diesel engine, including the capital charges.

The other question is, of course, the fuel question. There are about as many different kinds of fuel oils as there are of Diesel engine operators, referring to their suitability. A thing which he thought ought to be done in this country, and probably by the American Society of Mechanical Engineers, is to make a systematic study of fuel oils. There is quite a precedent for work along that line in the more recent European literature. For instance, in Switzerland, a very comprehensive study was made by actually running a Diesel engine for two and three weeks at a time on various fuels. Unfortunately, the fuels that were tried were all, with one or two exceptions, European oils, from Galicia and Roumania and Baku. There were only two American samples of oil used; one was an Oklahoma oil and the other a California oil, which means that only asphalt base oils were used in the tests.

Asphalt base oils are what ought to be investigated. The ordinary manufacturers haven't the time, and most of them haven't the inclination to allow the chief engineer to spend any great amount of time in making such investigations, and he thought that if the fund which is now in existence in the Society for carrying on research work could be drawn upon to carry through such experiments in one of the laboratories of our leading schools under the supervision of several faculty members—impartial men—he thought very good results would be obtained.

Referring to a few examples of what his experience had been on asphalt base oils, Mr. Setz said there is no standard definition for asphalt. Asphalt is defined sometimes as the residue which remains after heating the oil for a certain number of hours at a certain temperature in the open-air bath, as it is called. What remains after such a heating process is ordinarily called asphalt. But the residue contains many other things than asphalt, so that is not a conclusive test at all.

He had had one of the greatest surprises in his life when he started out the first Diesel engine in the Southwest. They told him the oil contained 50 per cent. asphalt, and he thought he might as well go home, because that engine would never run on that stuff. Yet to his great surprise, the engine ran and is running to-day with nothing else than that particular grade of oil. It is a California oil of 14.6 gravity, Baumé, and the engine can even be started and it it regularly started on that kind of oil—a thing which no engineer in Europe who has had European practice would believe possible unless he saw it.

Another method of determining asphalt is by a chemical analysis, and even in that there is no standardization, as Mr. Setz understood. He said he was not a chemist, and could not give conclusive definitions about it, but he understood that even among chemists, there is a difference of opinion as to just what asphalt is. He thought this question ought to be cleared up, and a standard adopted by means of which the oil is designated in the future. It would, he said, be a great help to manufacturers, and a far greater help even to users.

Mr. Setz referred to a publication which came out about a year ago, covering a lot of very interesting and important research work by the United States Geological Survey, covering asphalt base oils, California oils especially. The usual method of designating an oil in regard to its suitability for operation in Diesel engines is to give the gravity, either Baume, or specific gravity. If one goes through that pamphlet and plots graphically all the values that are given for these various California oils over the specific gravity, it will be found that the heat values range from 18,000 to almost 20,000 B.t.u. per pound, and that the percentage of asphalt contents given there varies from about 40 to 42 per cent. It will also be found that what is called kerosene varies also within certain limits. All these things indicate that specific gravity is not the only criterion for determining the value of fuel oil. This is one of the points that ought to be settled, and he believed that no better arrangement could be made than to having the American Society of Mechanical Engineers take this matter up, as it is strictly a mechanical engineers' proposition.

Another matter in connection with oils which Mr. Setz said was referred to several times in one of the papers, is the percentage of water. The percentage of water is not in itself enough to designate the oil as to its suitability for Diesel engine use. For instance, he had been operating on a Mexican crude oil which contained over 2 per cent of water, and the engine ran for quite a while very nicely. All at once it began to run jerky, iregular, and finally, it shut itself down. After investigating he found out that this Mexican crude oil was so heavy that the water remained in it suspended in very small drops, and did not separate out but very little. These very small particles of water, had been pumped in gradually with the oil into the injection valve—not into the cylinder, but into the injection valve on the atomizer plates. That piece of apparatus which will be found described in one of these papers, serves the purpose of disintegrating the fuel before it is injected, and the atomizer plates have a temperature high enough to evaporate the water. This water vapor rose inside of that injection valve space to the upper end of the injection valve, and there gradually condensed and formed a drop big enough so that afterwards, when it was blown into the cylinder, it shut the engine down. The Diesel engine will run on almost anything, but not on water, so there is where the water content would have an effect.

Another oil which contained about 5 per cent of water did not cause any trouble at all, because the oil was of such a constituency that the water was easily separated and could be drawn off; no water came into the cylinder at all.

Another feature of California oil especially, Mr. Setz finds, is the contents of the salts. These salts in the oil dissolve, and when the oil is burned in the cylinder, they form a deposit that, being a form of silicate, is a very effective grinding medium, and will wear out cylinders. Some do not show the effect at all, and others show it in very pronounced manner. This is another thing that ought to be investigated in connection with oils. If the Society could make a systematic investigation, Mr. Setz thinks it would be of great benefit

to this new industry, which promises to become of far greater importance here than it has reached in Europe.

R. L. Rowley asked Mr. Setz what was the smallest size of four and six-cylinder engines, and also the weight now adopted for Diesel work in European practice?

H. R. Setz said the question of weight is entirely dependent upon the speed of the engine. Up to a short time ago, in order to meet requirements of smaller submarine construction, speeds were increased and weights reduced beyond what is considered desirable limits to-day. Later practice is tending towards heavier weights and more rigidity in the engine, so as to insure longer life.

C. R. Weymouth said there is no class of investigators, or no class of experimenters that deserve more credit than the men who have developed and are developing the Diesel engine. They have had to face almost insurmountable difficulties, and he thought the degree of success that they have accomplished is remarkable. They have not, however, conquered the field, and there is a great deal to be said that is not in favor of the Diesel engine, and it was that portion of the subject that he wished to cover briefly.

His own experience had not extended to the Diesel field. About fifteen years ago his company undertook to exploit the Westinghouse gas engine on this coast. They installed between half a dozen and a dozen Westinghouse engines averaging from 50 to 100-h. p. Within two or three years time, after these engines were installed, he thought, every one of them was out of commission. He remembered a letter written to an engineer in connection with one of these plants operating a pump, and this letter was by a person who wished to ascertain the reliability of that type of engine. The party answering the letter stated that it was the most satisfactory gas engine that he knew of; they had made some alterations since it was first installed—they had removed the piston rod and the piston and had put an electric motor on the other end of the shaft, and it was then working perfectly.

Following this period there was installed at Martin's station near this city probably the largest gas engine plant in the United States, other than in the steel industry. This plant had four 5000 h. p. gas engines built by the Snow people. These engines were to run on manufactured gas; they were not involved with any problems of moisture, or silt, or asphalt. It is a well-known fact that the engines were never accepted; after a few years trial, at great expense, the engines were rejected, and their failure cost the International Steam Pump Company the sum of about one million dollars.

Mr. Weymouth asked the Diesel gentlemen here why it is that if engines designed to run under less difficult conditions result in failure, that a much greater degree of success can be expected from the Diesel engine. He knew the Diesel engine had attained a great degree of success, but he didn't understand the reasons for it, and would like to hear from them on that subject. He thought all engineers would admit that the Diesel engine is the most efficient type of prime mover known, and it is probable that no other type of prime mover will ever closely approach it in efficiency. He thought, however, that the majority of engineers would agree that that one advantage is about the only advantage of the Diesel engine, and that, starting from the saving in fuel resulting from its use, there must be subtracted a good many items of operating expense which result in a final operating cost which is not anywhere nearly as favorable as it might appear from the operating efficiency.

When we consider an engine operated with cast iron cylinders, with a temperature of the fire of from 2500 to 3000 deg. and with a piston floating in this flame, the difficulties of complete combustion under those conditions will be appreciated. As a result of the high temperatures and the other attendant troubles from the presence of moisture and silt, the operating troubles of the Diesel engine multiply, and in most of the plants that he had knowledge of, the operating cost is a material figure.

The Diesel engine was developed in Europe where, as a spur to its development, they had the highest fuel cost of any locality, and the saving based on this high fuel cost was such as to warrant a considerable margin in covering such losses as maintenance, high repair cost, operating costs and depreciation. In Europe also they were able to obtain at a comparatively low rate the highest skilled mechanics; they were able to do machine work with a degree of accuracy not formerly known in this country. All of which conditions were conducive to the best development of the Diesel engine. When the Diesel engine is transferred to the Pacific Coast, however, it will find probably the cheapest fuel cost of anywhere in the world. With crude oil at 60 cents a barrel, the fuel is one of the least items of the cost of a power plant, and whatever the percentage of this fuel saved, it means a small saving in dollars and cents.

Furthermore, we have in this country men who are not highly developed in the operation of delicate machinery, and it cannot be expected that the Diesel engine will arrive at its best until after quite a number of years. In our mining regions, where the Diesel engine would find its best development, men are found who are little better than tramps in a great many cases, as men who are skilled mechanics can secure profitable employment in the coast cities, and it is quite a problem to obtain operators who will stay in these unattractive desert locations.

Mr. Weymouth referred to Mr. Adams' paper on page 7: " The Diesel engine is in use to-day in almost all places where a steam engine or turbine might be used." He said that is a very broad statement and might easily be misleading, and the best way to answer a statement of that sort is to go immediately to an extreme. He mentioned that the Commonwealth Edison Company of Chicago is to-day contemplating the installation of a single turbine of 50,000 kw. capacity, and he compared that with an installation of Diesel engines. The largest Diesel engine built in America to-day, that he was aware of, was an engine of about 800 kw. capacity, and of about five cylinders per engine. It would require 60 engines of that size to develop this 50,000 kw. capacity. There should be, say, from five to ten engines reserved; if this reserve figure be called ten, there should be 350 cylinders in a Diesel engine plant to develop the capacity of one steam turbine.

If we go to the question of labor, it will be seen what an enormous number of men would be required. As to the

question of floor space, it would probably be found that there is not a single tract of land in the city of Chicago available for a plant of that capacity. That comparison may be unfair and probably is unfair to the Diesel engine, because he understood they are building larger sizes in Europe, although at the present time these are still in the experimental stage.

On page 14, Mr. Adams gives a comparison of the most efficient steam plant with the most efficient Diesel engine plant. He assumes an efficiency of 34 per cent for the Diesel engine, and an efficiency of 20 per cent for a steam turbine plant. Mr. Weymouth said he knew of his own knowledge that it is possible to operate a steam turbine plant under its most efficient conditions with oil fuel, without undue expense of first cost; that is, with 100 per cent load factor (which is the basis that Mr. Adams is talking on) obtaining 300 kw-hr. per barrel of oil. Taking the ratio of 34 to 20 and multiplying it by 300, that would be for the economy of the Diesel engine plant 518 kw-hr. per barrel of oil. He knew of the records of a number of Diesel engine plants, but he didn't know of any plant which is operating as efficiently as that. The best claims that he knew of are in the neighborhood of 0.7 lb. of oil per kw-hr. And if this be taken on a light oil, which will weigh about 300 lb. to the barrel, it would give somewhere from 400 to 450 kw-hr. per barrel of oil for the Diesel plant. Mr. Adams gives, in his paper, an economy of 447 kw-hr. per barrel of oil, which he thought was a fair comparison.

Mr. Weymouth pointed out that Mr. Adams gives a comparison on page 20 of the cost of the small turbine and the small Diesel engine plant, rating this at 600 kw. He said Mr. Adams had in mind, no doubt, a fair comparison which would be used, thinking of a plant which would be used by a small municipality. In making this comparison the Diesel engine appears at its very best, and the steam plant appears at its very worst. In a plant of 600 kw. maximum capacity, he didn't think that even the advocates of the steam turbine would contend that it is best adapted for this work. There have recently been developed some small steam engines on the uni-flow principle and an engine also of the four-valve type, which are giving remarkable economies; they can be operated on superheated steam and will show better performance in the small units than the steam turbine.

The steam turbine has, of course, an undisputed field in units of larger size, and most people agree that above a 1000 kw. the steam engine has little field. The economies given for the turbine plant may be representative of the steam turbine, but are not representative of the best that is obtainable with steam, and for a steam engine plant properly designed, the fuel consumption would be materially less than indicated.

With respect to the selection of units, Mr. Weymouth didn't think that an engineer would select a 200 kw. and a 400 kw. unit for any municipal plant. The day is past when we put in several sized units in a given station. We don't try to fit the load curve with unit sizes, and in any plant the units should be about the same sizes, for the purpose of duplication and for simplicity in repairs. Even with steam engines he would say that for a 600-kw. plant the unit size should not be less than 300 kw., and probably three units or 300 kw.

For the Diesel plant Mr. Adams selected in one case three 200 kw. units, and in another case one 200 kw., and another 400 kw., but there are no spare Diesel engines. All the Diesel people will agree that a spare Diesel engine is necessary. If this is provided for, it multiplies the first cost of a plant in proportion to the spare, and the fixed charge is increased in this ratio.

On the other hand, in providing the spare engine of the turbine unit, it is not necessary to provide the complement of spare boilers and stacks and boiler house, and the additional spare is provided at a less cost than in the case of a Diesel plant.

Mr. Weymouth said the labor costs are not high enough for the steam plant, and are considerably too low in the case of the Diesel plant. The maintenance cost is taken at eight-tenths of 1 per cent for the steam plant, which is too low, and one-half of 1 per cent for the Diesel engine plant, which is many times too low.

Regarding maintenance, he said that the California State Railroad Commission, in passing recently on the maximum power cost, had allowed $1\frac{1}{4}$ per cent as the maintenance of a steam plant, and he didn't think the Diesel plant could be figured at anywhere near that cost.

Referring to the fixed charges, 14 per cent has been estimated as both the total of fixed charges for the steam plant and the Diesel plant; in both cases this includes the item of 6 per cent depreciation for both types of unit. The whole question of the selection of a Diesel plant or a steam plant for a small unit station will depend upon the relative figures assigned for depreciation. There are none of us in this country that know anything about it, and any figure today is more or less an intelligent guess. He had talked to a number of people who have had European experience, and they told him that the depreciation of the Diesel plant is about the same as a good steam engine. He had asked one of their marine department for some figures on the life of steam engines, and had received a list of steamers operating on this Coast since 1880 or 1881, over thirty years. The depreciation on that basis would be something under 3 per cent. He knew of Diesel plants which had been entirely rebuilt in less than five years; that is, their vital parts.

Taking the figures that Mr. Adams has given for the total cost of operation on a 25 per cent load curve, on 95 cent oil, his power cost is 1.3 cents per kw.-hr.; on $1.50 oil it is $1\frac{1}{2}$ cents per kw.-hr. There are any number of steam plants all over the country which will show much lower generating cost than that, including all of the fixed charges. There are steam plants on this coast which are operating at easily one-half of those costs.

The Diesel engine has the same economy and almost the same cost per horse power in small units as large units, and the improvement for the larger sizes would not grow at a rapid rate; it would probably be some better than indicated. He would say that Mr. Adams has made a very unhappy selection in taking a 25 per cent load factor to figure out a Diesel engine. He doubted if the advocates of the Diesel engine would pick a situation of that sort, or even recommend their engine for that load. It is well-known that the Diesel engine is best fitted for loads near 100 per cent load factor, because there the saving in fuel is enough to offset some of the greater fixed charges and operating costs.

In connection with Diesel plants working in desert loca-

tions where there is a scarcity of feed water, where there is generally a large content of scale forming matter, Mr. Weymouth asked if the Diesel engine cylinders and jackets are designed to permit the easy removal of the scale which is certain to accumulate. A steam plant, working with surface condensers, he said, is a good salt factory, due to the evaporation of water, and there is a very rapid accumulation of scale in the tubes. He knew of one plant where it was necessary to shut down the condenser every 28 hours, and to drill out the tubes with a twist drill. That condition would prevail in the jackets of the engine. It can be overcome by designing the engine to remove the scale.

Mr. Weymouth remarked that Mr. Setz gave an interesting record of an engine which had been running something like twelve years, but that he didn't give any information as to the kind of oil used, whether it contained silt or other impurities which would give rise to cylinder wear and cylinder ring trouble.

In connection with the submarine practice of the United States, they have on that Coast the greatest amount of Diesel engine experience. The submarines were among the first Diesels on the Pacific Coast. They began with crude oil, but changed successively until they found it was necessary to run with a rather high gravity oil, something similar to Star oil, of about 30 gravity, before they could overcome their troubles.

In connection with the recent discussion as to why so many of our submarines are out of service, it has been pointed out by some of the authors of the Navy, writing articles for journals such as the Army and Navy Journal, that it has been found very difficult to keep these engines in reliable condition. The first report on the sinking of the submarine F-4 at Honolulu, mentions the difficulties of the Diesel problem in general, the unreliability of them, and the difficulty of keeping them in regular operation, but does not assign that as a reason for the sinking of the submarine.

Mr. Weymouth would say in closing that he thought these papers are both interesting contributions to the Diesel engine situation, but he regretted, and he thought all engineers would regret, that it is either not possible to give more reliable information, or it is not the disposition to give more complete information regarding the actual cost of operation of going plants.

A very complete report on this subject was made by the National Electric Light Association in 1912, consisting of reports on 34 stations. That information, however, is not as complete as it should be, and it is claimed that the engines now being designed are better built than the engines that were then in operation. But if an independent engineer today, is to pass on the problem of the relative merits of the Diesel plant, or a steam turbine plant, or a steam engine plant, he can find a great mass of information as to the operating costs and economies of the steam plants, but he will hardly be able to go beyond the stage of guaranties by the Diesel people as to their operating economy.

What we need are records of the life of Diesel engines so that we can estimate intelligently their depreciation and operating costs in the shape of labor, and the maintenance cost, and when that is at hand we will be able to decide what the future will be in California.

Mr. Weymouth said in closing that about two years ago he had the pleasure of showing Dr. Risert, a prominent German engineer connected with the Augsburg factory, over some power plants on the Pacific Coast. As he understood, Dr. Risert was one of the foremost Diesel engine designers in Germany, and he made the statement that while he was very favorable to the Diesel engine from the standpoint of its operation, the fuel cost on this coast was so low that he would not advise his people to attempt to cultivate the field here.

The Chairman: Mr. Dickie, then said they had had both sides presented very fully in regard to the Diesel engine. He was sorry that they did not go a little more into the marine Diesel engine, because he was somewhat interested in that. About five years ago a prominent shipowner in San Francisco wanted to try the Diesel engine; he had a boat building for his lumber business, and wanted an engine of 1200 h. p. The owner told him that he could spend $100,-000 on that engine if he wanted to, so he wrote to a firm of engine builders whom he knew very well and could depend on. They asked for samples of the oil to be used, and he sent then some twenty samples of oil from the California wells, just as it came from the wells. They would not undertake to build any Diesel engine that would run and be depended upon with that kind of fuel. On that account the application of the Diesel engine to the Coast shipping service stopped, and there has been no other attempt made that he knew of to bring the Diesel engine to service on that Coast. However, he said they may get to a Diesel engine that can be depended upon—and, really, he said, up to certain sizes, they are dependable to a certain extent, although the operating expenses, as shown by Mr. Weymouth, are pretty high, and the engine room force have to be all skilled men.

Mr. Dickie said they had one ship in there not long ago with 2200 h. p., which is a very small installation for a ship, and it had ten certificated engineers. That wouldn't go here, he said. A Swedish certificated engineer doesn't get very much wages; he is paid about the same as we have to pay a fireman here, and that makes quite a difference. All these things have to be taken into account when we come to the matter of deciding whether the Diesel engine, or some other form of engine is the best thing to use for any specific purpose that we have in view.

A. H. Goldingham said in response he thought most of the criticisms had been on the Diesel engine rather than on the hot surface type engine. He called attention to the fact that his paper was on the heavy oil engine, both the hot surface and the Diesel. But there were two things that he would refer to.

First of all was the cleaning out of the water spaces. In the later designs of engines this has had particular attention. First, there is a separate liner for removal in the cylinder, so that the scale can be removed, and also hand holes are provided, so that they can be well taken care of, both in the cylinder head and in the cylinder itself.

Second, with regard to the cost of operation, there is no question but that the oil engine, to have its best advantage, must be where fuel is expensive and where the load factor is high. The oil engine, as he had pointed out in his paper, to show to the best advantage, must work at or near full load all the time. Of course, its great advantage is the economy of fuel. Where you get very cheap fuel its advantage fades away slightly.

PAPER BY G. H. MARX AND L. E. CUTTER

## DISCUSSION

L. D. Burlingame remarked the fact that Prof. Marx has carried out his series of investigations to cover one of the features which go to make up a successful gear whets our appetites for further investigation along the lines of efficiency in gearing, and to cover other important factors which go to make up successful running gearing. Some of the other factors are the matter of wear and the matter of quiet running, and we can only get at the most satisfactory or successful system of gearing by taking all of these matters into consideration, rather than taking one. While an investigation of this character is of value as giving data on which we can base further investigations, before we can decide what is the best system of gearing, we must have these other matters also taken into consideration.

For example, the Committee on Standard System of Involute Gearing, which investigated various systems, found from their tests that the $14\frac{1}{2}$ deg. angle gear gave a decided greater percentage efficiency, and a quieter running gear. In arriving at a compromise which will give us a system of gearing for universal application, these things must all be taken into consideration, and as he understood, the matter could be carried further if funds were available. It seemed to him that a very desirable use of funds which might be available for research work could be made to carry out further experiments along these lines.

The question of strength of gearing, Mr. Burlingame stated, is affected very possibly by this consideration: that with the small pressure angle ($14\frac{1}{2}$ degrees for the Brown & Sharpe system) the pinions being the weaker element, that is, where a small pinion runs into a large gear, the engineering solution is to make the gear of steel, or if further strength is required, to temper the pinion and thus get the benefit of strength without sacrificing the question of wear or of quiet running.

In the paper of Prof. Marx, it is interesting to note on page 7, where the figure is given for the actual breaking load of the Brown and Sharpe gear, that the curve of actual break is materially higher than the theoretical curve on which the figures are based. This is interesting as showing that the figures as given in this pamphlet are on the conservative side and are such as can be used with safety, that is, with a larger margin of safety than perhaps the actual facts would warrant.

It is also interesting to note the suggestion as to contact with more than one tooth during the action of the gearing, with a question mark against the three teeth being in action during certain parts of the action of the gearing. This is largely a matter of accuracy of cutting and of the system on which the teeth are based. He doubted if in many cases three teeth are actually in operation, from the fact that the point of the tooth of the ordinary Brown and Sharpe gear is eased off for quiet running in a machine; that would probably prevent actual contact unless under extremely heavy pressure.

Mr. Burlingame felt that Prof. Marx's contribution is one of direct value to the engineering profession, and sincerely hope that the work can be carried further.

Kate Gleason said that one of the very interesting things to her that Professor Marx had found in studying the Lewis formula as compared to the work he is doing, is that the strength did not fall off on high speeds, as he found, as rapidly as Mr. Lewis found it. The trouble they found is just as Prof. Marx found, that the strength does not fall off at the high speeds, but the load is apt to be so much harder —the starting and stopping at the high speed—that a great deal more has to be allowed in practice than in tests.

For instance, in rolling mill machinery, running at a high speed as it often does, if they are trying to run mills with motors almost double the strength has to be given than would in even the Lewis formula, whereas, in the Lewis formula on machine tool gears it is found more than ample. It seemed to her that as the loads come on so quickly, it acts almost like a hammer on the gears and crystallizes the material, and though the material may be plenty strong enough for the first month or two, it will disintegrate if not provided for, perhaps by putting in nickel steel, or something of that kind.

Miss Gleason stated that they found in the same way in testing worm gears, that they will not show up on a test at all as they do in practice. We have had papers here showing efficiencies up to 90 per cent on worm gear drives, but when we go out in practice, where the load comes down and makes so much friction, we cannot get 20 per cent out of it sometimes.

G. H. Marx replied that it had been peculiarly interesting to him to have Miss Gleason discuss the paper, because it was about twenty-five years ago, when he was working for the Gleason works in Rochester, that his first interest in gearing began, in connection with the preparation of a trade catalogue and pamphlet—a small treatise on gearing, which he had to get out. That interest had never failed, and although these experiments have been very tardy in coming off, he was very glad to have them done now.

What has been said by both speakers he heartily agreed with. In the first place, these experiments are limited merely to the question of strength, which is a very small part of the whole problem, and they are limited to cast iron gears. But he said, the only way to get an investigation done is to take a small portion of the field and cover it as thoroughly as can be, and then take the neighboring area and perhaps go into that. It takes a great deal of time, as any one who has carried out any investigation knows, to clean up even a small portion of a question like this.

As to the question of the falling off according to speed, of course, it was as Miss Gleason said, and she must remember that these tests were made under running conditions. He said their plea is that where there is shock, where there are reversals of stress, or where the stress is suddenly applied, that factor should be taken care of by a proper factor of safety and not in a velocity coefficient. So they have separated those and have a factor of safety in their formula, in which the question of the matter of application of load, or the question of reversal of stresses is provided for.

# JOINT MEETING AT PROVIDENCE

*An unusual joint meeting of local sections of the Society took place recently in the joint gathering of the Boston local section with the affiliated society, the Providence Association of Mechanical Engineers. The occasion was made notable by the attendance of several prominent engineers from distant points, who delivered addresses on engineering topics, and the opportunity for social intercourse was taken advantage of by a dinner gathering at which 520 were seated, preceded by a number of excursions to industrial plants in the afternoon. The meeting was said to be one of the most successful ever conducted by an engineering organization.*

A JOINT meeting of the local section of the Society of Boston and of the affiliated society, the Providence Association of Mechanical Engineers, was held at Providence, R. I., on November 18, 1915. Members and friends to the number of 290 arrived in Providence by special train from Boston early in the afternoon, and proceeded at once to visit several of the manufacturing plants of the city.

At five o'clock they arrived at Brown University to inspect the engineering laboratories, and at 6.15 P.M., 520 engineers and friends sat down to dinner at the Narragansett Hotel, the largest gathering of engineers that ever dined together in Providence. Many could not attend on account of lack of room.

After dinner the visiting engineers were welcomed by Mr. Arthur H. Annan, President of the Providence Association of Mechanical Engineers, who said:

We are in the midst of a great industrial centre. Its prosperity depends upon the success of those industries, which in turn depend upon the successful efforts of their engineers. Their work is done singly or in small groups. We are constantly, and increasingly, witnessing the great achievements of organizations by concerted action, and who more than the engineers should appreciate and profit by such proceeding? I believe that we may profit and extend our influence and coöperation to every phase of our industrial, commercial, educational, social or any other function of a civilized community which is influenced by the work of engineers.

Dr. W. H. P. Faunce, President of Brown University, was then introduced by the toastmaster, William Howard Paine. Dr. Faunce said that he represented the "poor college professor," while the engineers represented, not the "malefactors," but the factors of great wealth. Continuing, he told of:

A certain country preacher, who met a famous baseball pitcher, and said to him: "What is the cause of the difference in our salaries? I get $500 a year and you get $5000. Moreover, I work twelve months in the year and you work only three and yet my salary is $500 and a miserable little parsonage thrown in, and you get $5000. What is the reason for that?" And the famous pitcher said: "I suppose the difference is all in the delivery!" While there is a great deal of difference in our delivery, yet there may not be after all so much difference in the things we are aiming at. On an evening like this I am conscious of the unities rather than the divergencies.

It has often been assumed in America that the men of thought were utterly distinct from the men of action; that the men of thought are to be found inside of the college fence, and that the men of action are outside in the world doing things without any deep intelligence. But the engineering profession stands for the union of thought and action. It stands for intelligence and labor, for thoughtfulness put into industrial and commercial enterprise, and says to all the world: "Your labor is thrown away, unless you think as you work." On the other hand, it is equally clear that thinking will come to little unless somehow it is harnessed into the great creative activity of the age."

Following Dr. Faunce, addresses were given by Professor Charles E. Munroe, Washington, D. C., on Explosives and the Engineer; by Morris L. Cooke, Philadelphia, Pa., Mem. Am. Soc. M. E., on Experiences of an Engineer in Public Office, and by M. C. Rorty, New York, on The Development of a National Telephone System.

After Mr. Rorty's address moving pictures were shown of the construction of and scenes along the transcontinental telephone line. At 9.30 P.M., through the courtesy of the American Telephone & Telegraph Co., telephone connections were made with the Exposition grounds at San Francisco, Cal., every person present having a receiver connected to the transmission line so as to hear the long-distance conversation.

## EXPLOSIVES AS AN AID TO ENGINEERING

BY CHARLES E. MUNROE,[1] WASHINGTON, D. C.,

Non-Member

Engineering is one of the oldest of the professions. But as we contemplate the temples, the tombs, the pyramids, the obelisks, the fortifications, the highways, the aqueducts, the viaducts, the mines and tunnels and the other monuments to man's achievements which have come down to us from most ancient civilizations in many parts of the world, in view of the tools, appliances and materials now at the command of and in use by the engineer, one is led to inquire into the means by which such work was then accomplished.

Although gunpowder is recorded as having been used as a propellant at the siege of Baza by the king of Granada in 1323, its first appearance in military engineering operations, as recorded, was at the siege of Merat in 1397, where it was used for springing mines. In 1585 it had come to be used in marine devices, for, in that year a bridge in Antwerp was destroyed by a floating torpedo. The first reputed application of this agent to peaceful pursuits is attributed to Martin Weigold (Weigel) at Freiberg, Saxony, in 1613. Guttmann doubts this because as late as 1617 Lohneyss wrote "on the soft veins they work with pickaxes, but in the solid ones with gad and mallet." Guttmann recognizes that the art of blasting was naturally an evolu-

[1] Dean, George Washington University

Presented at joint meeting of the Providence Association of Mechanical Engineers and the Boston local section of The American Society of Mechanical Engineers, held at Providence, R. I., November 18, 1915.

tion and holds that the first practical application of which there is authentic record was made by Caspar Weindl on February 8, 1627, in the Oberbiberstollen of Schemnitz in Hungary.

For over two centuries gunpowder remained the only available blasting agent, but in 1845 Schoenbein discovered gun cotton, in 1846 Sobrero discovered nitroglycerine, in 1866 Nobel invented dynamite and a new era in explosives for engineering uses began. Guttmann dates the application of these new sources of energy to blasting as 1854, but without citing person, substance, or place. In the early days of blasting the charge in the bore hole was ignited through the stemming by spills or squibs, consisting of straws, quills or rush tubes filled with fine powder. In 1831 William Bickford invented the running fuse in use to-day wherein a thin, continuous core of powder, along which the fire might slowly travel at uniform and determined rate, was enclosed in a jute tube. In 1867 Nobel introduced detonators.

To-day the preferred method of firing blasts is by electricity; therefore Americans should be interested to know that history states that Franklin, in his Letters on Electricity (June 29, 1751), was the first to suggest the employment of frictional (or static) electricity for the ignition of gunpowder, and that in 1831, Moses Shaw of New York, made the first application of this method to the firing of mines. Meeting with practical difficulties in putting his invention into industrial operation Shaw, on June 1, 1831, appealed to Dr. Robert Hare of the University of Pennsylvania for advice and assistance, and the latter applied his famous deflagrator or voltaic battery and a wire bridge to this use with such complete success that, though the generators for the electric current have been altered in form and character, and the detonators in details, the method devised by Dr. Hare is the method which is to-day in universal use throughout the world for the firing of blasts, mines, or torpedoes by electriicty. This method was demonstrated for use in warfare when in 1843 Samuel Colt blew up a brig under full sail in the Potomac from Alexandria, which was 5 miles distant from the brig, though in 1839 Sir Charles Pasley had removed the wreck of the Royal George at Spithead by the use of low tension fuses.

The blowing up of Flood Rock in Hell Gate, in New York City, was successfully accomplished October 10, 1885. Flood Rock had a superficial area of nine acres, about 250 sq. ft. of which was above water. The rock consisted of hornblende gneiss, with intersecting cross-veins. A sea-wall 7 ft. high was built around the island, and two shafts were sunk, one 67 and the other 40 ft. deep. The main shaft was used for removing the excavated rock in blasting out the headings. The smaller shaft was used for the tubes conveying the compressed air which drove the drills. The first series of headings branched out from the main shaft at a depth of 40 ft., and from the bottom of the shaft another series diverged directly under those above. The headings branched at right angles every 20 ft. and were 60 in number in each tier. The double system of headings was employed to gain a sufficient depth after the explosion without the necessity of dredging out to the extent that was found necessary at Hallet's Point. The total length of tunneling was about four miles, consisting of 24 galleries running north and south and 46 running east and west. The longest of these was 1200 ft. in length, 6 ft. wide and 10 ft. high. There was a thickness of from 10 to 25 ft. between the roof of the top tier of galleries and the water. There were 467 pillars, 15 ft. square, left to support the roof. The whole rock was honeycombed with tunnels, about 80,000 cu. ft. of rock having been removed.

There were drilled in the pillars and roof 13,286 chambers for holding the cartridges, each chamber being 3 in. in diameter and about 9 ft. deep. These chambers were filled with rackarock cartridges, of which there were about 47,000 used, each being $2\frac{1}{2}$ in. in diameter and 2 ft. in length, and containing about 6 lb. of the explosive. In addition to the rackarock cartridges, several hundred ordinary dynamite cartridges were used, to which the wires leading to the firing batteries were attached. The shock resulting from the explosion of these dynamite cartridges caused the explosion of the rackarock. Upwards of 285,000 lb. of explosives were used in the charge.

The wiring in the mine was divided into 36 circuits, the batteries attached to these circuits being stowed in a toolhouse on the rock. The wire of the primary circuit which actuated the electro-magnet that closed the secondary circuits was led across to the Astoria shore on the morning of the explosion. The firing-key was about 1200 ft. from the mine.

Two siphons, one 12 in. in diameter and the other 3 in., were set at work at 10 A.M., October 9, flooding the mine, and they completed their work early the following day. The first effect of the explosion was to produce a rumbling noise, and then to project a mass of water over an area of about 1200 sq. ft. to a height of about 150 ft. Masses of rock rose in the midst of this water to a height of from 40 to 50 ft. The explosion lasted about 30 seconds. As the water fell a dense cloud of yellowish smoke arose and floated over the Astoria shore.

After the explosion the rock appeared undisturbed, though on close examination it was found to be somewhat fissured. However, it slowly settled, and by October 13th the entire rock was below water. It was not intended that the rock should be broken very fine, since with the appliances at hand pieces of from ten to fifteen tons in weight could be most economically handled. The operation covered nine years, and cost upwards of $1,000,000. (Proc. Nav. Inst. 9, 755; 11, 281.)

More than 30 years ago the author began a study of the conditions of efficiency in the use of explosives and in a paper published in Van Nostrand's Engineering Magazine for January 1885, which dealt with attacks on armor, demonstrated that the maximum degree of confinement for the explosive and penetration by the projectile were the essential conditions. In 1898, apropos of the use of the dynamite gun at Santiago, I returned to the problem and published my results in Cassier's Magazine of that year, of which I gave a resumê in an address to the citizens of Cleveland on behalf of the American Association for Advancement of Science and which appears in the Popular Science Monthly for February 1900 as follows:

> There is a widespread misapprehension in regard to the devastating effect of these high explosives, for when unconfined the effect even of large charges of them upon structures is comparatievly slight. At the Naval Ordnance Proving Ground, so long ago as 1884, repeated charges of dynamite, varying from five to 100 lb. in weight, were detonated on the

face of a vertical target consisting of eleven 1-in. wrought-iron plates bolted to a 20 in. oak backing, until 440 lb. of dynamite had been so detonated in contact with it, and yet the target remained practically uninjured; while at Braamfontein the accidental explosion of 55 tons of blasting gelatin, which was stored in railway vans, excavated but 30,000 tons of soft earth. This last may seem a terrible effect, but the amount of explosive involved was enormous and the material one of the most energetic that we possess, while if we compare it with the action of explosives when confined, its effect becomes quite moderate.

At Fort Lee, on the Hudson, but two tons of dynamite placed in a chamber in the rock and tamped brought down 100,000 tons of the rock; at Lamberis, Wales, 2½ tons of gelatin dynamite similarly placed threw out 180,000 tons of rock; and at the Talcen Mawr, in Wales, seven tons of gunpowder, placed in two chambers in the rock, dislodged from 125,000 to 200,000 tons of rock. We might cite many such examples, but on comparing these we find that the gunpowder confined in the interior at the Talcen Mawr was over forty-two times as efficient as the explosive gelatin on the surface at Braamfontein, while the dynamite at Fort Lee was over ninety times as destructive.

These views have received but little consideration from officials in this country and our Government has gone on spending money in the testing and use of devices which were certain to prove ineffective. However, I confidently point to Liege, to Namur, to Antwerp and to the effects of a multitude of perforating high explosive shells used in the present war in confirmation of the principles I developed. One has but to scrutinize the pictures in the Scientific American for October 30, 1915, showing the effect of shell fire on the Emden to be convinced of the accuracy of these conclusions.

Shortly prior to 1898, and while he was Chief of Bureau of Ordnance, U. S. N., I was asked by Captain Sampson to assist in the tests of armor piercing projectiles then being conducted at Indian Head by Comdr. Couden by securing a high explosive charge for them. This was done and after proving an excellent degree of fragmentation in the fragmentation pit a shell containing 8.25 lb. of the explosive was fired through 14.5 in. of the Harveyized armor of the U.S.S. Kentucky and exploded on the inner side. So far as records go this had then never been approached.

When Admiral Sampson took command of the fleet he wrote me asking my assistance in securing high explosive charges for the armor piercing projectiles of his fleet. I delivered his message and used my best endeavor, but the material called for was not sent and it remained for the Japanese to be the first to demonstrate in practice the soundness of these principles.

This study was continued and extended to bore-holes in blasting operations by my pupils, Clarence Hall and W. O. Snelling, and their results and conclusions were published in 1912 as Technical Paper No. 17 of the Bureau of Mines under the title "The effect of stemming on the efficiency of explosives." It was naturally of interest to learn that a manager of a considerable mine reported a saving of $50,000 in his explosives' account in a single year by following the methods for using stemming taught by this research.

More recently Edgar A. Collins has stated in Min. Sci. Press, Vol. 110, p. 790, 1915, that he has found in practice where 30 per cent ammonia gelatin was being used in a given mine a saving of 25 per cent in quantity of the explosive was effected by increasing the depth of the tamped stemming above the charge and that as a consequence the amount of explosives issued to the miners had been cut to from 10 to 20 per cent of that formerly issued.

It should always be remembered that the gases produced by explosives in exploding have other properties than that of yielding larger volumes than the solids from which they are produced, for some of them are poisonous. The kind of gases produced differs with the kind of explosives used and the way in which it is used. Nitric esters and nitrosubstitution compounds and the mixtures, such as dynamite, made from them, may yield poisonous nitrogen oxides and cyanogen, and poisonous and inflammable hydrogen sulphide and carbon monoxide. But if the explosive be properly compounded, well confined, and fully detonated, these harmful gases will not be produced, for the gaseous products will then be largely composed of water and carbon dioxide; and though carbon dioxide may cause unconsciousness and even death, it does so only when it forms a large proportion of the atmosphere. Blasting powder and gunpowder-like mixtures give off poisonous and inflammable hydrogen sulphide and carbon monoxide under all conditions of explosion.

The production of inflammable gaseous products underground, especially in coal mines and bitumen mines, is most hazardous. The production of poisonous gases, either below ground or on the surface, is a source of danger, and if such gases are formed they should be removed by ventilation before anyone is allowed to approach the working place. Neglect of this precaution led to the death of 7 persons and the rendering of 40 others unconscious from gas poisoning following the firing of 21,000 lb. of blasting gunpowder at the Crarae quarry, Loch Fyne, Scotland, on September 25, 1886. The quarry was situated in a basin in a hill with sides rising 25 to 250 ft. and was approached by a narrow gorge. The blast was fired in the presence of an audience of over 1000 persons and at least half an hour after the blast 120 got into the quarry to observe the effect, and within five to six minutes after entrance they began to fall, overcome by the poisonous powder gases entangled in the crevices of the rock that had been thrown down.

In a large engineering project in the West nine men lost their lives as a result of the poisonous gases produced on the detonation of 40 per cent strength gelatin dynamite in a long tunnel. After igniting the blast the men retired about 500 ft. to wait for the smoke to clear, and while they were waiting the smoke drifted slowly over them, and then, owing to some change in the air current, drifted slowly back again. The men felt the usual symptoms of carbon monoxide poisoning—slight choking, nausea, profuse perspiration, and headache—but they all revived upon reaching the open air about an hour and a half after the blast had been fired. Within a short time, however, the men began to cough and spit bloody mucus and show other symptoms of nitrogen peroxide poisoning. In less than three days 9 out of the 13 men who had been in the tunnel and exposed to the fumes had died; the other four, as well as those who went in with the motor to bring out the men, were ill for days and even months after the catastrophe.

It was soon after the accident mentioned above that special studies of the noxious gases evolved on the detonation or combustion of different explosives were undertaken by the Bureau of Mines to determine whether improvements could be made in the composition of explosives with a view to increasing safety in mining.

# EXPERIENCES OF AN ENGINEER IN PUBLIC OFFICE

BY MORRIS L. COOKE, PHILADELPHIA

Member of the Society

Mr. Cooke prefaced his remarks by saying that he must admit experiencing somewhat of a thrill as a result of this large and enthusiastic meeting of engineers—more than could crowd into the hall. This event and the recent accomplishment of the engineers of his home city in their remarkable campaign for increasing the membership of the Philadelphia Engineers Club, by which it was raised from 560 to 2300, indicated to him a growing strength on the part of the engineering profession, and of a corresponding opportunity open to the profession.

He said that municipal administration, in which he had had a part, had been conducted on the assumption that there were almost no fundamental differences between public and private businesses. He believed that he and his associates had the right to claim that this was distinctly a novel idea in municipal administration, and that as the years went on it would be looked upon more and more as an important step forward. He said further:

The public official cannot do at all times all that he would like to do, which is as true also in private establishments. We sometimes assume that those in nominal control in business really control. But whether we speak of the men or the management, such control is only relative—never absolute. If much that we dreamed during the past four years was frustrated by those opposed to us, we must admit that it would be just as true in industry or anywhere else.

As an offset it can be claimed that anything good which is accomplished carries further because of the publicity which frequently comes to public business. The difficulty usually is that public officials are not always able to get publicity, nor to make the people understand their purposes and work. A man in private business frequently answers that he does not have to give his reasons—even resents being asked for them; but a public official should beg for widespread public discussion of public problems, for only in this way can he get the necessary public support for those things which deserve support. Too frequently the public has either half information or misinformation.

This assumption about the similarity of public and private business has stood us in good stead at every turn. Thus we have assumed that our Civil Service laws were only a codification of the best practices of private business and that considerations which would make John Wanamaker, Baldwin Locomotive Works, or any other good employer, either employ, discharge or discipline, should hold with us. Acting on this theory we have not once failed to get the man we wanted through Civil Service and the courts have not reinstated a single man, although it has been necessary to discharge hundreds.

In the broad group of municipal engineering activities none are of more importance than those classed broadly under the head of public utilities, including therein steam and electric railroads, gas, water and electric plants, and telegraph and telephone companies. When we came into office the municipality exerted almost no control over these properties, most of them both privately owned and privately operated.

The city had almost no reliable information about these utility companies and therefore was in no position to enforce the most modest demands either for improvements in service or readjustments in service. No one will ever know the difficulty we have experienced in ascertaining enough of the facts to put us in a fair negotiating position. Practically every American city is in the same situation. And yet every city should at all times be in possession of all the facts about every utility which serves it. We will look back some day upon this period of utility hide-and-seek as one does on the dark ages.

We look upon our activity in this field as our greatest accomplishment. We have not only wrought many local improvements in the utility situation in Philadelphia, but our influence has been felt all over the country. Largely as the outcome of our local difficulties, has come the National Utilities Bureau with a distinguished directorate, which with headquarters in Philadelphia is acting as a counselor and guide in utility matters to cities all over this continent. As a standardizing and economizing agency the influence of this bureau is already making itself felt. It provides the only forum in this country for the expert and untrammeled discussion of utility problems.

However great we may feel to be the opportunity of the engineer in this municipal field, the public will come only half way. As a profession we must go forward to meet our opportunity. No narrow view as to the scope of engineering can be tolerated, and we should bring to our aid the most exalted conception of service which we can command. Ever since I have been a member of The American Society of Mechanical Engineers, I have made the effort to arouse the interest of my fellow members in our responsibilities to the public as contrasted to those we owe to our profession. After four years of direct association with the engineering problems of the third largest city in this country, the necessity for your coöperation is all the more apparent. There is no national engineering society taking a special interest in municipal engineering. I wish ours could do so.

William Ostwald—one of the greatest leaders of present-day Germany—has called our attention to a fundamental difference between the science of the future and science as we know it to-day, or more particularly as we have known it in the past.

The change from a pseudo-science to a real science only comes when we begin to use the knowledge we have as to the present and the past to build a future which we then proceed to make come true. The astronomer bases his predictions as to the future on the race-long accumulation of data. The hour at which to-morrow's sun will set may have been figured out centuries ago and perhaps with an inspiring degree of accuracy, and yet such figurings have not the slightest influence on the event. In the same way species have come and gone and their life histories have been in no wise influenced by man.

In California, however, a Burbank pictures a flower with heretofore unheard of qualities—a new color, a new shape, or perhaps a new perfume. Then by combining and recombining known varieties under laws, some of them known and some of them not even recognized, and—presto! the sought-for flower. Again a Flexner in New York or an Erlich in

Frankfort draw the specifications for a bacillus that shall bear down some enemy of the race, and forthwith it is produced.

It does not require a great imagination to picture this force broadly at work in the field which has to do with the interrelations of men. In greater and greater degree in the science of human institutions we will have the power, if we can get that point of view, to write the formulas for the future according as we see what will be for the benefits of our kind.

Engineering has had much of service in it. I am told by municipal researchers that, taken the country over, no other class of officials has a better record for probity or the painstaking execution of public trusts than have our municipal engineers. No one of us will underestimate the meaning of such a statement. Inspiring though a good record may be, all its value is lost if we do not use it as a stepping stone to something greater, to deeper service, to a more profound understanding of all that life of which we may be a part.

Engineering must more and more be looked upon as the great coördinating branch of human endeavor. To bring order out of chaos can be rightfully claimed as our job. More and more our client must be all the people.

# THE DEVELOPMENT OF THE NATIONAL TELEPHONE SYSTEM

BY M. C. RORTY,[1] NEW YORK

Non-Member

Man has been called the "tool using animal," and his progress has been so closely identified in the past with his skill in the manufacture and use of tools that we hear frequently of the stone age, the age of bronze, and the iron age, as representing broad divisions in human evolution. But it is not proper to speak in terms of tools of the hand alone. We might, perhaps, more accurately speak in terms of the development of the tools of the mind, and might divide the years of man into the dumb ages, the age of speech, the age of picture writing and hieroglyphics, the age of the alphabet, the age of printing, and, finally, the ages of the telegraph and the telephone.

It was no accident when Alexander Graham Bell, more than 39 years ago, in the City of Boston, spoke into such an instrument to his assistant, Thomas A. Watson, over a line less than 100 ft. long, the first words ever transmitted by electrical telephone. Bell had been an instructor of the deaf and dumb, and, perhaps more than any man of his day, was practically familiar with speech and the mechanism of speech. He had that vision, inspiration, and enthusiasm which, in the inventor, is without price. His years of study and experimentation gave wings to that first telephone message.

It was no accident, also, that in the development from crude beginnings, which reached its logical climax on Monday afternoon, January 25, 1915, this same Alexander Graham Bell, in our offices in New York, talked with this same Thomas A. Watson in San Francisco, over a circuit stretching 3400 miles across the continent, and serving to unite into one great system 9,000,000 telephones connected by 21,000,000 miles of wire.

And, finally, it was no accident that, in the last few days, this apparently finished work has been added to by transoceanic speech by wireless—with a whisper swelling, if need be, to hundreds of horse power, and spreading simultaneously in vast etheric waves, from Washington to the Eiffel Tower in Paris, on one side, and, on the other, to the distant Island of Hawaii.

Hundreds of inventors and engineers, in the 40 years since Bell and Watson held their first telephonic conversation, have labored ceaselessly for these great results, and levies have been made upon every branch of science and mechanics.

The problem has been a difficult one, not from its magnitude, but rather from the very subtlety and delicacy of the forces with which the engineers had to deal. It was not much more difficult to string wires from Denver to San Francisco than from New York to Denver, but the physical construction of the line was the least of the troubles. The real problem was to make that line talk, and to send 3000 miles with the breath as its motive power. The voyage of the voice across the continent is practically instantaneous. If its speed could be accurately measured, a fifteenth of a second would be nearly exact.

But the breaking of speed records is not the only thing which the telephone must accomplish. It must also guarantee safe delivery of the millions of tiny passengers which it carries every few seconds in the form of electrical waves created at the rate of about 2100 per second.

A breath against a metal disk changes air waves into electric vibrations, and these vibrations, millions upon millions of which are required for a single conversation, must be carried across the continent and produce the identical sound waves in San Francisco that were made in New York or in Providence. This task is so delicate and so fine as to be gigantic.

The transcontinental telephone line is much more than a mere scientific achievement. No one who stands in a modern telephone exchange in a great city and watches the tides of human activity ebb and flow—rising now swiftly with some great public crisis, falling with equal swiftness when the crisis passes—can fail to realize that this line is but the last link in the building up of a vast, sensitive, and truly universal service.

Such a service was anticipated in a remarkable way by the inventor-prophet Bell when he wrote, just two years after his first telephonic conversation had taken place:

> It is conceivable that cables of telephone wires could be laid underground, or suspended overhead, communicating by branch wires with private dwellings, country houses, shops, manufactories, etc., etc., uniting them through the main cable with a central office, where the wires could be connected as desired, establishing direct communication between any two places in the city. Such a plan as this, though impracticable at the present moment, will, I firmly believe, be the outcome of the introduction of the telephone to the public. Not only so, but I believe, in the future, wires will unite the head offices of telephone companies in different cities and a man in one part of the country may communicate by word of mouth with another in a distant place.

But even so farseeing a man as Bell must seek aid when it comes to establishing a public utility of continental scope. And we shall fail in our duty to-night, if, in paying tribute

[1] Engineer, American Telephone and Telegraph Co.

Presented at joint meeting of the Providence Association of Mechanical Engineers and the Boston local section of The American Society of Mechanical Engineers, held at Providence, R. I., November 18, 1915.

to the inventor, we fail to pay tribute, also, to the organizer, the constructor, and the engineer.

For many years this line from ocean to ocean has been the dream of Mr. Theodore N. Vail, president of the American Telephone and Telegraph Company, the goal toward which he has pushed and toward which he has steadily led his associates. This has not been an idle fancy of a dreamer, but the prophetic vision of a practical, forceful, capable man of unlimited business knowledge, who can see everything in telephony, except impossibilities. He not only cannot see impossibilities, but he will not admit that they exist.

At Mr. Vail's side through most of these years has been a slightly built, active, keen-eyed man, John J. Carty, chief engineer of the American Telephone and Telegraph Company, and the organizer and directing head of what is, perhaps, the most remarkable group of technical workers that has ever been assembled for the accomplishment of a specified purpose. Mathematicians, physicists, chemists, experts in design and manufacture, and experts in field construction—each man has been selected with the utmost care, and practically every university and scientific school in the country can count its graduates within the group. Team work, imagination, and thoroughness have been the secrets, if secrets there be, of their success. To award individual credit among so many who are deserving would be a hopeless task. The greatest element in the whole sustained program has been leadership.

As a mere piece of construction, the building of a telephone line across the continent is impressive. For instance, the line crosses 13 states; it is carried on 130,000 poles. Four hard-drawn copper wires, 165/1000 of an inch in diameter, run side by side over the entire distance, establishing two physical and one phantom circuit. One mile of single wire weighs 435 lb., the weight of the wires in the entire line being 5,920,000 lb., or 2,960 tons of copper. This amount of copper is required for the transmission lines alone. In addition, each one of the physical circuits has some 13,600 miles of fine hair-like insulated iron wire 4/1000 of an inch in diameter, in association with it for the magnetic cores of its loading coils.

Simply to string this immense amount of wire across the continent, to set the poles and insure insulation, to conquer the innumerable difficulties offered by land, water, forests, mountains, desert, rivers and lakes, was in itself a task of no mean magnitude.

But a still greater task has been the building of the human organization that maintains the line day by day in operative condition and that maintains also the millions of active telephone terminals spread from ocean to ocean, without access to which the copper of the transcontinental circuits might as well be back in the mines from which it came and the poles back in their original forests. No group of isolated companies could build a transcontinental telephone line, or, if it were once built, could maintain it for a week in operative condition. The single-minded purpose that caused the line's construction must operate with equal singleness of mind each minute and each hour of the day to maintain it in service.

Such an organization, also, and all of the many similar organizations that are lending themselves in good spirit to the public service must have the wherewithal to work, the assurance of reasonable profits and public good will and coöperation to-day and for the future, if they are to do the great constructive work that the nation demands.

For a final word, it is something more than a pet phrase to say that, in this country, we need only transmission—not translation. Differences in language are vital things. The great European conflict is perhaps even more a war of languages than it is a war of peoples and dynasties.

It may be an extreme statement to say that if we had had a national telephone system before 1860, the Civil War would not have been fought, but it is probably true that the railroads, the new canal, and our universal telephone service have all combined to weld our people together in a lasting unity.

# FOREIGN REVIEW AND REVIEW OF THE PROCEEDINGS OF ENGINEERING SOCIETIES

*At a meeting of the Council on October 8, 1915, it was voted to approve the recommendation of the Publication Committee to include in The Journal a review of the world's technical press. In accordance with this resolution, the Engineering Survey will contain, in the future, in addition to the material as hitherto published, abstracts from engineering publications in the English language. This feature will be developed gradually, however, beginning with the publication of a few abstracts in each issue, selected with a view to placing on record the more important developments in mechanical engineering.*

## ENGINEERING SURVEY

In engineering, there are still a good many "traditions" which have been accepted some time in the past and persist mainly because a general impression prevails that the thing is right and is therefore to be accepted by everybody as being right. This condition continues until some one takes the trouble to investigate when and how such a law or rule was proved to be right, in which case it often develops that it never was proved to be right, and that it is, in fact, entirely wrong. Such a situation existed in the early days of electrical engineering, when, with respect to direct current motors, there was a sort of accepted dogma to the effect that the external resistance should be equal to the internal resistance: This held the efficiency of the generator down to about 40 per cent. Then came Thomas A. Edison, who stated that he did not see why the internal resistance should be so high; that what he wanted was to deliver current outside and not inside. The Jumbo was built and showed an efficiency of over 80 per cent. Apparently similar considerations led to the assumption that a valve on an air compressor or pump will close without shock if the closing occurs exactly at the dead point in the motion of the piston. As a matter of fact, this is not only practically impossible, but theoretically wrong, and in order that the valve should close free of shock, the closing must occur *after* a reversal in the motion of the piston. This, and several other considerations of a very interesting nature, are brought out in the article on the analysis of the motion of valves, by Klepal, in this issue.

### THIS MONTH'S ARTICLES

In the section, Aeronautics, are abstracted two interesting articles—one of direct practical importance, on aeronautical timber, by J. E. Huson, in which the author, among other things, calls attention to the great variation in the mechanical properties of timber, depending upon the original size of the log, time of felling, interval between felling and sawing, and the position of the test pieces relatively to the heart of the tree. The other article in the same section refers to the application of the law of similarity to balloon models, and among other things, brings out the importance of the variation of the coefficient of air resistance with the nature of the surface of the body moving through the air.

A description of an improved type of suction producer gas locomobile is given. Its main feature is an arrangement permitting the separation of the cooler from the producer and, as a result, a far more effective cooling than has previously been obtained on locomobiles of this type.

An extensive and well illustrated abstract of an article on German apparatus for the measuring of pressure and velocity of gases will be found in the section on Measuring Apparatus. The question of apparatus of this nature became of particular importance in Germany since the adoption by the German Society of Engineers, of the standard rules for testing air compressors and blowers.

An article on the holding power of nails is abstracted indirectly from the Indian Textile Journal.

In the section, Steam Engineering, are described some tests of a 300 h.p. superheated steam locomobile, of interest because it shows a comparatively low fuel consumption and the ability of the plant to carry a very large overload. A brief description of an improved dry back marine boiler and some data of tests of same are given.

A description of a laundry for the handling of ships' washing is abstracted from a German publication.

In a paper before the American Society of Civil Engineers is described the automatic volumeter, an apparatus intended to gage the flow of fluids by the collection of a proportional part of the flow, or its equivalent, in a small vessel where it can be readily measured at any time. In order to design this apparatus, the coefficient of flow through small orifices had to be established, and experiments along these lines, partly reported in the abstract, have revealed totally unexpected conditions. These experiments were made both with water and with oil.

Professor G. L. Larson, in a paper before the American Society of Heating and Ventilating Engineers, reports tests on the recirculation of washed air, in which, among other things, he calls attention to the fact that recent investigations (some of which have been reported in the Engineering Survey), have shown that what is known as bad air is caused preeminently by the physical conditions of the air with respect to temperature, humidity and movement. It is both unnecessary and uneconomical to supply large volumes of air in order to obtain good ventilation. Carbon dioxide as high as 20 parts of 10,000 does not have a bad effect upon ventilation, and ventilation by recirculation is both efficient and economical.

An important series of tests on the shearing resistance of reinforced concrete beams is published in the Transactions of the Canadian Society of Civil Engineers. Of especial interest is the establishment of the fact that stirrups tend to quite materially raise the ultimate strength of he beam and that when they are set 4 in. apart, shearing failure is practically eliminated.

From the Memoirs of the College of Engineering of the Imperial University of Kyoto, Japan, is briefly abstracted a

paper on the Leonard control applied to mine hoists, of interest because it gives general equations of the resisting moment of hoist as well as equations from which may be found the mechanical relations between acceleration and retardation.

The Purdue Engineering Review reports some tests of standard and clasp brake rigging for passenger train service, made lately on the Lake Shore and Michigan Southern Railroad, and indicating that on the whole, the clasp type of brake is the more proper design to use for heavy passenger equipment.

Vulcanizing experiments on plantation Para rubber, made at the laboratory of the Department of Agriculture of the Federated Malay States, indicate that if the rate of cure be known or ascertained under specific conditions, vulcanized rubber having similar chemical properties, can be made from all good samples of " first latex " rubber so that both plantation and wild rubber may be used equally well. The same tests have established the fact that the rate of cure itself is due to the presence of some substance in the latex, which probably acts as a catalyst and accelerates the rate of cure. The paper suggests the issuance of certificates giving the correct rate of cure and mechanical properties at that cure.

From the bulletin of the University of Illinois are reported experiments made for the purpose of determining the influence of temperature on the strength of concrete.

**Aeronautics**

Aeronautical Timber, J. E. Huson

The paper discusses the question of the use of various timbers for aeroplane construction from a purely technical point, without regard to the special conditions of supply created by the current events in Europe.

The natural fallacy in considering timbers which besets engineers used to calculations in metals is the unconscious assumption that all perfect specimens of timber are homologous, which is by no means the case. A flawless piece of ash sawed from the outside of a tree will vary in specific gravity, tensile strength, elasticity, etc., from a piece of the same log sawed nearer the heart and both would differ from timber riven instead of sawed. Timber sawed from young trees would differ from that obtained from older trees grown in the same locality. Timber only partially seasoned gives different values from timber " bone dry." Ash grown in sandy soil differs from that grown on a clay or chalk soil and that grown in a coppice from that in the open field. That grown at a high altitude and bleak aspect differs from that in a lower and more genial position.

Tables of tests therefore are to be handled with caution and their information would be more valuable if they were supplemented with full descriptive notes as to the region, original size of log, when logs were felled, interval between the felling and sawing, how long in the stick after sawed, and the position of the test pieces relatively to the heart of the tree.

Two important points should be steadily borne in mind: *first,* that timber is mainly a natural growth and therefore varies with all of the many factors affecting growth, and *second,* that time is an essential factor in proper seasoning. When ordering timber for aeroplanes, it should be remembered that the smaller the dimensions asked for, the greater the choice of timber for quality and no attempt should be made to get large planks of such a size as will cut economically for two or three different sizes.

It is much more difficult to obtain ash straight in the grain for a good length than it is to procure silver spruce absolutely straight. Further, there is a greater variation in the properties of ash than there is in those of silver spruce; hence, when designers have the option of specifying silver spruce or ash, and can afford the extra bulk and increased head resistance to bring the strength of spruce up to that of ash, it would seem prudent to prefer the former.

As to hickory, although the best grade is stronger than the best ash, yet it is a wood which varies considerably and it is doubtful whether on the whole, weight for strength, it has any advantage over ash. It is, however, extremely tough and is probably the best wood for skids. It should not be used in hydroplanes as it is subject to rot in water.

The writer does not recommend kauri pine for aeroplane work. It is extremely liable to be knotty, is heavier than silver spruce and inferior to it in physical properties. Rock elm has no advantage over ash in strength and other properties and has the disadvantage of being usually sold in solid logs.

Mahogany is used by two or three contractors. In working out designs it should be borne in mind that the actual thickness of mahogany is a saw-cut less than the normal thickness. It is valuable in that it is not affected by water and if carefully chosen should be a very good wood for aeroplane work.

Yellow cedar will not rot in water and hence it is suitable for hydroplane boats. Parang is a species of mahogany, stronger and more fibrous than the Honduras variety. It has been used for dirigible propellers. Teak is a highly suitable wood for workings in hot climates. Oak is not used in aerial construction (*Aeronautics* (London), vol. 9, no. 102 (new series), p. 219, September 29, 1915, 2 pp., *gp*).

Law of Similarity and Balloon Models, C. Wieselsberger

At the Model Testing Laboratory of Aeronautics connected with the University of Göttingen, a series of tests have been carried on for some time on the application of the law of similarity to the case of balloon models and on the influence of the nature of the surface of the model on the air resistance. In this article are described tests on four models, the purpose of which way to establish, *first,* the applicability of the law of similarity in general, and *second,* the variation of the coefficient of air resistance with the nature of the surface.

The four models had the general shape shown in Fig. 1A, having been made by electro deposition of copper. The surface was carefully smoothed with emery and then covered with a layer of japan varnish so to prevent oxidation. The midship diameters were respectively 93.6, 132.1, 188.7 and 268.8 mm. (3.68, 5.13, 7.42 and 10.58 in.). Measurements were made in an air stream having velocities up to 23 m. sec. (75.46 ft. per second). The data of these tests are shown in Fig. B, by the full drawn lines, the coefficient of air resistance $\psi$ being plotted as a function of the Reynolds coefficient,

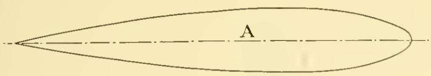
$$R = \frac{vd}{\nu}$$

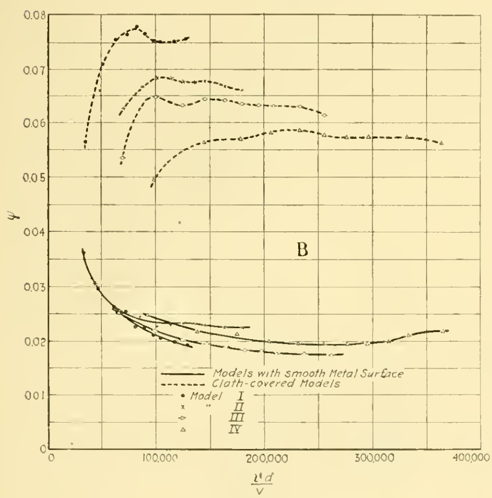
In accordance with the law of similarity, the coefficients of resistance of all models ought to lie on a single curve. Actually, however, each model seems to have a curve of its

own, which is principally due to the fact that it proved to be impossible to construct models absolutely similar to one another, and there are, in each case, slight deviations from the accepted shape. Experiments have shown that these deviations have an unexpectedly great influence on the resistance of the body. It has been further found that the coefficient of resistance rapidly decreases with the increase of the Reynolds coefficient, but when the Reynolds coefficient becomes very large, an increase begins in the coefficient of air resistance. The strong decrease of the coefficient of resistance with the increase of air velocity corresponds to the transition from a laminar to a turbulent flow and when the Reynolds coefficient exceeds 200,000, the flow is distinctly turbulent. The velocity of air could not be reduced sufficiently to obtain values of ψ for the laminar state.

The models were then covered by balloon cloth with the rough non-rubberized side upward, and the resistance measured anew. The data of these measurements are indicated in Fig. B by the broken lines. It was not to be expected that the law of similarity would hold for this case since the roughness of the surface could not be geometrically the same for all the models. What is remarkable, however, is the entirely different shape of the ψ curves, which in this case rapidly increase with the increase of the Reynolds coefficient and assume an irregular wave-shaped formation.

The influence of the nature of the surface was further investigated on one of the models (No. III): first the bristling fibres on the surface of the model were burned off by a rapidly moving flame and the resistance then determined. The result was very remarkable (Fig. C). The coefficient of resistance which was formerly quite small at low velocities, increases to two and a half times at the greatest velocity available. Next the cloth-covered model was treated by the Cellon-Emaillit process as usually applied to aeronautical cloth (this process usually requires the application of three layers of Cellon-Emaillit A, which is then rubbed off by fine sandpaper, after which two layers of Cellon-Emaillit B are applied). This treatment reduced the resistance to still lower values than had the models with smooth copper surfaces. Next, the models so treated were provided with a layer of High-Brilliancy Emaillit varnish, which gave them a mirrorlike surface. A further reduction of resistance was obtained, within the region of velocities available, only with the Reynolds coefficient below 160,000, but at higher velocities the ψ curve rises again somewhat.



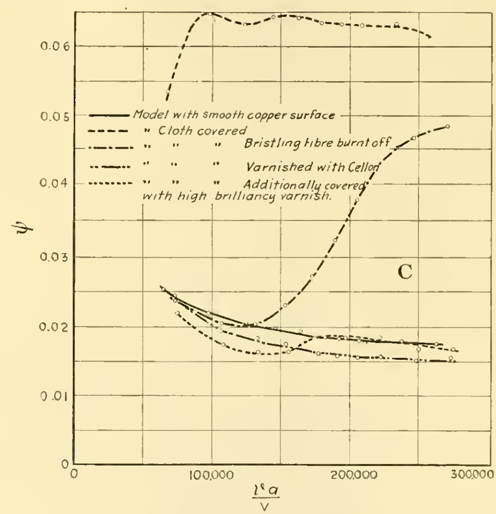




FIG. 1 RELATION BETWEEN NATURE OF SURFACE OF BALLOON MODEL AND AIR RESISTANCE

In the next article, the same author describes investigations on the measurement of air resistance in a free air stream and in a tunnel with circular plates and flat planes (*Mitteilungen aus der Göttinger Modellversuchanstalt, Zeits. für Flugtechnik und Motorluftschiffahrt*, vol. 6, nos. 17 and 18, p. 125, September 25, 1915, 8 pp., 9 figs., *et*).

**Internal-Combustion Engineering**

LOCOMOBILE DRIVEN BY SUCTION PRODUCER GAS, Gwosdz

Description of an improved modern type of suction gas producer locomobile built by the machine factory of the Royal Hungarian State Railways.

The important requirement in the design of a suction gas locomobile lies in compactness of arrangement of the main elements of the plant; i.e., the gas producer, cleaner and engine. In older designs, the producer and gas cleaner were located in the same shell, which served also as a support for the engine. In addition to the fact that such a construction made access to the gas producer in case of repairs considerably more difficult, there was also the disadvantage that the cleaner, which had the duty of not only cleaning the gas, but also of cooling it, was too much exposed to the heat from the gas producer and received the gases at too high a tem-

perature, which increases the difficulty of cooling. The next step was to arrange the producer and cleaner separately, but even here they were so close together that a free cooling of the gas before entering into the cleaner did not prove feasible.

The Machine Factory of the Royal Hungarian State Railways has placed on the market two designs, in both of which (the latter has an annular shape and is placed around the evaporator *c*). The gas is first cooled to quite a considerable extent in this connecting pipe, and also by contact with the front wall of the cleaner, likewise exposed to the atmosphere. This boiler wall is also part of the entrance chamber *e*, which on the other side is separated from the washing chamber by a wide wall, *f*, ending in a sharp edge

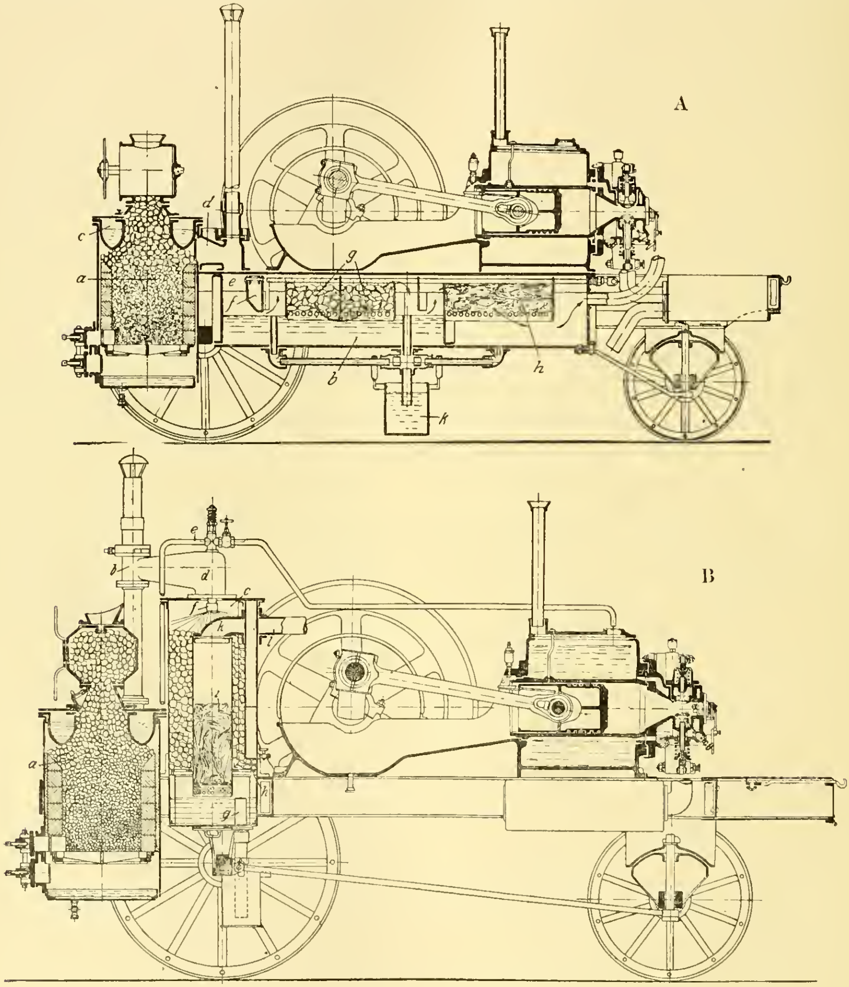



Fig. 2 Improved Suction Producer Gas Locomobiles

the above difficulties are said to have been obviated. The first of these designs is shown in longitudinal section in Fig. 2A. The producer *a* and the engine are located on separate under frames, with the engine lying directly on the flat cooling and cleaning shell *b*. The producer is separated from the cleaner by an intermediary space, fully exposed to the atmosphere, and connected with it by a wide conical pipe *d*, which branches off at the level of the gas collector and coming down to nearly the water level. From the entrance chamber, the gas goes to two scrubbers *g*, and from them, through a dryer *h*, filled with wood fibre, to the gas engine. The water which collects in the cleaner is allowed to escape through the overflow pipe to the trap *k*. On the front side of the gas producer there is located a hand driven fan for blowing the fire. All the cleaning chambers have side openings, closed by tight covers.

As fuel, coke, anthracite and charcoal may be used. With the latter, the attendance is especially simple and the cleaning is no more trouble than with a gasoline engine. This is due, of course, to the low ash content and the easy gasification of the charcoal. The favorable experience in running a producer on a suction gas locomobile with charcoal led to a still greater simplification of the cleaner.

In the design, shown in longitudinal section in Fig. B, the cleaner no longer supports the engine frame, but is a separate container located between the gas producer and engine frame, so that the gases in passing through it encounter considerably less resistance than in the former design. The gas producer *a* is suspended in the front part of the frame, and the gas passes from it through pipe *b* into the container *c*, located between the U-shaped beams of the frame. In the angle arm between pipe *b* and container *c* is built in the cooling water pipe *c*, provided at the opening with a nozzle *f*. The container *c* is equipped in its lower part with an overflow pipe *g* and sieve-shaped wall *h*. The latter is passed through in the middle by the tube-shaped drying tank *i*, located concentrically to the sides of the walls of the container *c*, this drying tank *i* being in its turn built in its lower part like a sieve. The top is connected by an elbow element, *k*, to the rear wall of the container *c*, and is connected with a long transmission pipe *l*, leading to the cylinder head of the engine. Container *c* carries both sieve *h* and some filtering material (coke) and the dryer space, *i*, is filled with clean iron filings.

The gas flowing through the bend *d*, goes therefore to the upper chamber of the container *c* through a sheet of water, and in doing so is effectively cooled. After it has passed through the coke filter of the scrubber and then through the dryer, it goes to the pipe *l*, in which it is further cooled on its way to the engine. This simplification of the cleaner and cooler results in a reduction of the power consumed in the suction. (*Neue Sauggaslokomobilen*, Gwosdz, *Zeits. für Dampfkessel und Maschinenbetrieb*, vol. 38, no. 40, p. 329, October 1, 1915, 3 pp., 3 figs., *d*).

### Measuring Apparatus

German Apparatus for Measuring Pressure and Velocity of Gases, E. Stach.

Descriptions of various apparatus for the measurement of pressure and velocity of flow of gases.

The simplest and most widely used apparatus for measuring pressure in gases is the vertical U-tube with alcohol or water for low, and mercury for average pressures. In order to increase the movement of the column of liquid there may be used two liquids of different densities as shown in the apparatus of Dr. Rabe, Fig. 3A. The liquids differ here both in specific gravity and in color and their dividing plane forms the zero point. Because of the displacement of the level of the liquid under pressure on the side of the lighter liquid, the displacement of the dividing plane is influenced by the ratios of cross sections and specific weights and, generally, dimensions and liquids are so selected that the deflection is at least twice as great as it would be with a water column. In order to throttle the movement of the liquid and to reduce the tendency of the two liquids to mix under strong variations of pressure, there is produced in the right hand tube of the apparatus a throttling by means of the glass ball *c*. When the pressure to be measured is above atmospheric the apparatus is connected at *a*, and when below atmospheric, at *b*.

Another apparatus, for fine measurements of pressures from + 0.01 to + 25 mm. of water, is diagrammatically shown in Fig. B. The vessel which contains the measuring liquid (distilled water) is divided by a partition into two air-tightly separated chambers *a* and *b*. When a pressure above atmospheric is measured, the connection is made at *d* and for measurements of pressures below atmospheric, at *e*. By means of a millimeter screw provided with a measuring wheel divided into 100 parts, the needle *s* can be screwed down until the galvanoscope *f* shows a deflection. Full millimeters are to be read on the scale *m* and fractions on the micrometer. The apparatus must be protected from vibration.

A manometer for fine measurement of fluctuating pressures is shown in Fig. C. It has a vertical measuring tube and is filled with absolute alcohol. It consists of a wide vessel made of cast iron provided with hose connections and a vertical stand pipe. Between the vessel and pipe there is located a cock shown in the front part of the drawing, by which may be effected either a direct connection or one through narrow brass tubes of different lengths located under the vessel. These last tubes act as a damper of the fluctuating deflections of the apparatus in accordance with their length which in its turn depends on the position of the cock. At first the pressure is connected without any damping and the oscillations are then quieted down by means of a gradual insertion of tubes of various lengths, whereupon rapid and correct reading of pressure can be taken. The reading is done through a small magnifying glass located adjustably on a laterally held bar. With this magnifying glass is connected a little mirror, giving an inverted image of the meniscus. A fine adjusting screw is moved until it appears through the magnifying glass that the tip of the screw and the image of the meniscus touch each other. The reading is actually effected by means of a nonius and magnifying glass on a micrometer scale divided into fractions of a millimeter. For measuring average pressures, both above atmospheric and vacua, mercury filled manometers constructed on the principle of a barometer are mainly used. Fig D shows such a vacuum gage built by R. Fuess. The sign "Marke z" indicates the exact level of mercury when the gage is not connected. The connection between the glass tube and screwed pipe-joint *mr*, which leads to the condenser or a similar apparatus, is made by means of a heavy hose *s*. The left tube (with the scale) is not as long as a barometer, since usually, for example in condensers, vacua from 60 per cent. on are of interest only. The scale to the left reads in millimeters of mercury, and to the right in absolute pressures. For gage pressures above atmosphere, such as occur for example with blowers, the left part is also made like a barometer tube, but of a length of about 1.6 m (41.7 in.) and pressures are likewise given in absolute units. For reading very low pressures, a so-called micromanometer is used, which is usually equipped nowadays with an adjustable reading tube and either a variable or a permanent zero point. The article describes the micromanometer of Recknagel and Berlowitz. They are not described as another micromanometer (Fuess) has already been described in *The Journal*. (October, p. 194).

*Indicating and Recording Pressure Gages:* The older types are described, such as the Ochwaldt gage. Of greater interest is the gage designed by de Bruyn, Fig E, and the line of apparatus built by the Hydro-Apparatus Company. As shown in Fig. F, in the latter motions of the float are

transferred to the indicator hand in the same way as in a spring manometer. In Fig. G is shown a combination of a recording pressure gage and a differential draft indicator. The recording of the differential draft with simultaneous retension of the indicating scale has been secured by raising the diagram drum and providing a second scriber. If it is and below it, due to the reversal of the valves of the chambers. For the variation of pressure above and below atmospheric, alternating by about the same amount, the zero point is located in the middle of the diagram. The section of such a diagram is shown in Fig. K. The abscissae give the times and the ordinates, pressures + 50 mm. of water. The nearly

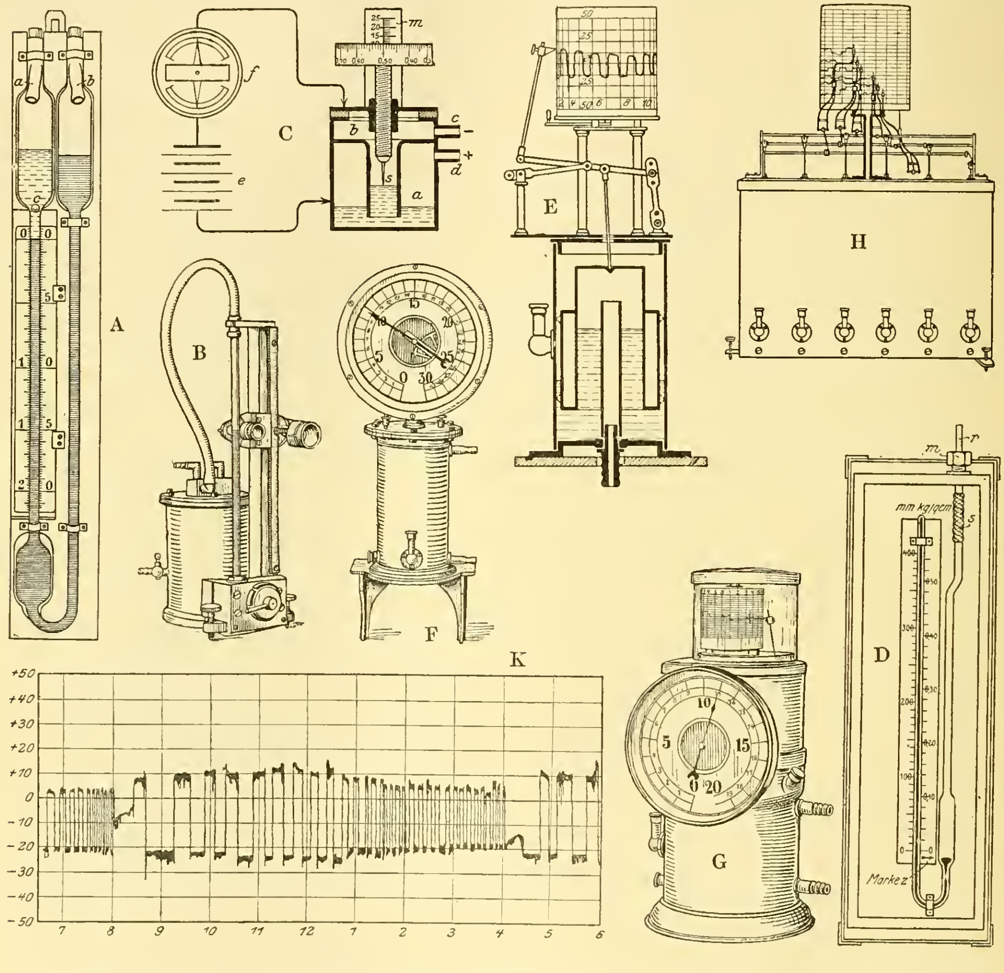



Fig. 3 A, Rabe Draft Gage; B, G. A. Schultze Pressure Gage for Fine Measurements; C, Prandtl Manometer for Measuring Fluctuating Pressures; D, R. Fuess Vacuum Gage; E, de Bruyn Pressure Recording Gage; F, Hydro Pressure Gage; G, Hydro Pressure Indicating and Recording Gage; H, Pressure Recorder for Six Points of Measurement; K, Diagram of a Pressure Recording Gage on an Open-Hearth Furnace

required to record the pressures from several points of measurement, the gage shown in Fig. H (for six points of measurement) can be used. It is self-explanatory.

For measurements on regeneration firing plants, such as open-hearth furnaces, coke ovens and glass melting furnaces, it is important to be able to record the time sequences as well as the height of alternating pressures above atmospheric

vertical lines indicate the times of reversal of the gas or air valves.

The article also describes the pressure recorder of de Bruyn for high pressures. (*Messgeräte für Druck und Geschwindigkeit von Gasen,* E. Stach, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, no. 41, p. 832, October 9, 1915, article not finished, *d*).

## Mechanics

Analysis of the Motion of Suction and Pressure Valves, O. Klepal

The motion of a valve embraces four stages: 1. Opening of valve; 2. Forward motion, away from seat; 3. Backward motion, toward seat; 4. Closing. In theoretical investigations it has hitherto been the practice to treat the stages 1 and 2 combined, but the author proposes to show that this method of procedure is not correct and may lead to wrong conclusions.

The opening of the valve is brought about by the motion of the piston. In order to overcome the pressure $p$, over the area $F$, above the valve (Fig. 1), the motion of the piston must exert below the valve a pressure $p_1$, which may be calculated from the equation

$$p_1 = p\frac{F}{F_1}$$

where $F$ and $F_1$ are valve areas above and below. To this must be added the pressure required for the acceleration of

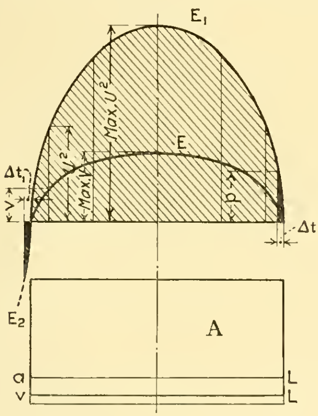



Fig. 4A Valve Motion Diagram for Pump

the valve mass, for lifting the weight of the valve (when the valve moves vertically) and for overcoming the friction at rest in the valve guides, together with overcoming resistance, due to the action of the valve springs. The difference in pressures $p_1 - p$ must be as small as possible. This presupposes narrow valve seats, and small weight and mass of valves as well as small friction and the balance of the mass.

*Up and Down Motion of the Valves:* After the pressure below the valve has forced an opening and a slit is formed between the seat of the valve and its cone, there commences a flow of fluid (either in drops or as a gas), through the cross-section $F_1$, this flow proceeding with a velocity which increases with the increased velocity of the motion of the piston (upward stroke) and decreases with its decrease (downward stroke). There act, at any point of its path $h$ (valve stroke) on the area of the valve, the following main and auxiliary forces:

*Main Forces*

*a* Impact of the stream of fluid $P$ (called in the discussion following, "stream impact").

*b* In the case of valves loaded by springs, the force of the spring $P'$ acting in the opposite direction.

*Auxiliary Forces*

*a* In vertically moving valves, the weight on the valve $G$.

*b* The friction in the valve guides $\pm R$, which acts always in a direction opposite to that of the motion of the valve and therefore changes its sign.

*c* The force $\pm B$, which produces acceleration of the mass of the valve and is supplied on the upward stroke by the stream impact and on the downward stroke by the valve

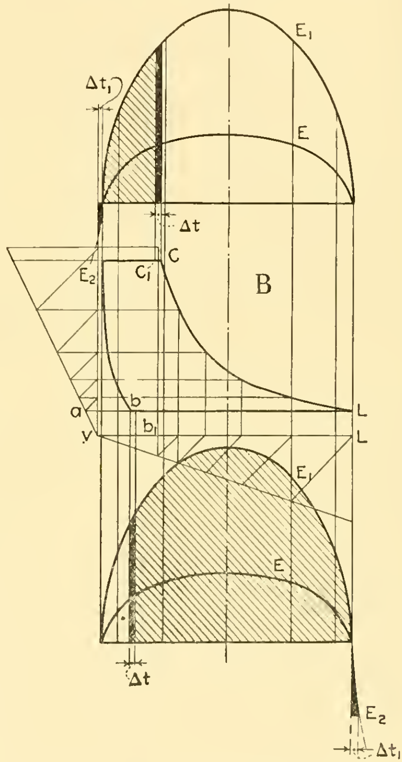



Fig. 4B Valve Motion Diagram for Air Compressor

spring. Hence, to the upward stroke of the valve applies the equation

$$P = P^1 + R + B + G \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

and for the downward stroke of the valve

$$P + R + B = P^1 + G \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

In the above equations, $P$, $P^1$ and $B$ are variable, $R$ may be assumed to be constant, and $G$ is constant. $G$ may be assumed to be known, as it depends entirely on the design of the valve. All the other variables are dependent on the magnitude of the stream impact and for the present this essential for the knowledge of the valve motion element is taken to be unknown, and the author considers it quite problematic whether its value can be at all established with a precision sufficient for practical purposes. If it can be done, it will require extensive and costly experimentation.

In this connection the author quotes what Professor Körner wrote in 1908 (*Zeitschrift des Vereines deutscher Ingenieure,* page 1842 and following): "Even with stationary valves and very simplifying assumptions, the direct analytical determination of the pressure (stream impact) exerted by the stream of water, presents insuperable difficulties. My experiments in this connection have not resulted in obtaining values which would be sufficiently complete and in agreement with the actual values, even though a certain functional dependence could be found. Still less soluble proved to be the problem when the motion of the valve itself exerted an influence on the pressure to be determined and hence, this method of research had to be abandoned."

It appears, therefore, that the magnitude of the stream impact cannot be determined by calculation. It may, however, be found graphically. Let $F$ represent the area of the piston in qcm., $f$, the area of free passage of the valve in qcm.; maximum $v$, the greatest piston velocity equal to the velocity of the crank pin in $m$; maximum $u$, the greatest velocity in the valve cross-section which can be calculated from the equation: $\max u = \frac{F.\max v}{f}$ in m. . . . . . . . . . . . . [3]

It will be assumed for the present that the magnitude of the stream impact is proportional to the square of the instantaneous velocity in the valve section. In Figs. A and B, the magnitude of the stream impact is represented separately for liquid pumps on the one hand, and compressors, air pumps and blowers on the other, respectively.

In correctly working pumps, it has hitherto been assumed that both the suction and the pressure valves remain open or closed during the entire stroke of the piston and that the stream impact acts on the valve during the entire stroke. It will be seen that this view is only approximately correct. Of decisive value so far as the motion of the valve is concerned is, however, the operating pressure and its influence will be here considered. In the case of pumps, compressors, etc., we have to distinguish two kinds of working pressures: *the working pressure exerted on the suction valve,* and *that with which the pressure valve is working.* Usually, except in the case of multi-stage compressors and air pumps, the working pressure at which the suction valve is operated, is approximately equal to atmospheric in the case of a compressor and is below atmospheric with pumps, in accordance with the suction head. Because of the final width of the valve seat there must be in the working cylinder above the suction valve a pressure below atmospheric which produces the opening of the valve. When the valve is lifted, the pressures above and below the suction valve are equalized and the suction pressure ceases to act on that particular valve.

The processes in the pressure valve occur in exactly the same manner. In the working cylinder, because of the final width of the seats, there must exist a pressure above atmospheric as is shown in equation [1]. Here again, when the valve lifts, the pressures equalize and the working pressure then prevailing no longer exerts any action on the lifted valve. In both cases, with the suction as well as with the pressure valve, the opening of the valve occurs *after* the piston passes its dead center; and not, as has hitherto been assumed, exactly when it is in dead center. The latter would involve an assumption of an infinitely narrow valve seat area, which is impossible to attain in practice. The recognition of this fact is of importance for our further investigation, viz., for the determination of conditions of quiet valve play.

In Fig. 4A, in the lower part, is given a theoretical indicator diagram of a pump (a rectangle). In this and in the following figures, *al* is the atmospheric line and *vl* the line of the absolute vacuum. The ellipse $E$ represents piston velocities with infinitely long connecting rods and maximum piston velocity *max-v* in the middle. From equation [3] can then be calculated the maximum velocity of the fluid in the valve cross-section, *max-u,* and its square plotted in Fig. A. The other points of the curve $E$, the ordinates of which represent the magnitude of the stream impact acting on the valve area at any point of the piston stroke, are calculated from the equation

$$u^2 : v = \max u^2 : \max v,$$

or

$$u^2 = \frac{v.\max u^2}{\max v} \quad \ldots\ldots\ldots\ldots [4]$$

The values thus calculated, when connected by a smooth curve, give the curve $E_1$, which, together with the horizontal line below, encloses an area which represents the power transmitted to the valve area during one valve stroke. Its area is sectioned. The meaning of the black strip will be explained later.

In compressors, air pumps and blowers, the amount of power transmitted to the valve area is different for suction and pressure valves and in addition to that depends on the working pressure. In Fig. B in the middle is represented a theoretical indicator diagram of the compressor. After the expansion of the gas in the clearance space, the suction valve, because of the existence of the pressure below atmospheric in the working cylinder, opens theoretically at the point of intersection $b$ of the expansion line of the clearance space with the atmospheric line *al;* the gas flows into the cylinder and its impact lifts the valve. The amount of power from the stream impact, transmitted to the valve area, is represented in Fig. B, at the bottom, by the area enclosed by the curve $E_1$, the vertical line at $b$ and the horizontal line below. This area is likewise sectioned, and the meaning of the black strip will be explained later. In a similar manner has been determined the amount of power transmitted from the stream impact to the pressure valve (see Fig. B, top). The area is a section and the curve $E_1$ has been determined in the same manner as in the case of the pump. The points $b$ and $c$ shift in accordance with the working pressure of the compressor and this causes a change in the power supplied by the stream impact.

From what has been said above, it appears that the action of the stream of fluid on the valve occurs not at the dead center of the piston, with pumps, and at points $b$ (suction valve) and $c$ (pressure valve) with compressors, but somewhat after that. The importance of this fact will appear later.

If the magnitude of the impact stream could have been analytically computed beforehand, the dimensions of the machine and the speed at which it will run would predetermine the required loading of the valve. In the case of spring loaded valves (hence, valves without rigid limitation of the length of the stroke which is in this case elastic), the opening of the valve lags behind the dead center of the piston and occurs without shock. The shock in the valve motion can occur only when the valve hits the seat. The opening of the valve and its forward and backward motion occur

without shock. If, now, we investigate the conditions under which a free-of-shock closing of the valve occurs, we see the following: *the action of the stream of the fluid ceases exactly at the instant of reversal of the motion of the piston.* At the same instant, and hence theoretically within an infinitely short time, the valve must close, which would require a theoretically infinitely great closing force necessary for the acceleration of the mass of the valve, and this is practically impossible. Hence the closing of the valve cannot take place when the piston is at its dead point and the closing of the valve before that instant is likewise obviously out of the question. The opening of the valve without shock occurs after the reversal of the motion, since it cannot be otherwise as the action always follows the impulse.

Vice versa, a shock-free closing of the valve may be expected if it occurs after the reversal in the motion of the piston and hence not, as has hitherto been assumed or striven after, exactly at the dead point in the motion of the piston. The valve closing must occur after the reversal of the piston, since action always lags behind the impulse, and in this particular case the acting force is the stream impact. Beside, to the case of the free-of-shock valve closing applies the same rule as to all other motion which occurs free of shock—to wit, the sum of all forces or works occurring during the motion must be, at the beginning and at the end of the motion, equal to zero.

Let us now follow up from Fig. A the motion of the suction valve.[1] The valve rises with the increase in the piston velocity up to the highest point of stroke; then its stroke decreases up to the dead point in the motion of the piston. Let us imagine that the valve, at the dead point of the piston, is not yet quite closed and that between the valve and its seat there is a tiny slit. Then, at the instant of the reversal of the piston, the liquid begins to flow back through that slit, the stream impact changes its direction and helps to close the valve. Simultaneously, at the reversal of the piston, there occurs in the working cylinder a slight increase of pressure above atmospheric, since in the slit between the valve and the seat the liquid is throttled. There is, therefore, a small difference in pressure between that above and that below the suction valve, which, together with the reversed stream impact, forces the suction valve against its seat. To the negatively acting (as far as the direction is concerned) stream impact, and the closing pressure of the liquid, there must be opposed a negative load on the valve, produced by the spring. In other words, the valve must be loaded negatively (in the direction away from the seat).

If we denote the pressure above atmospheric above the valve by $D$, then the equation [2] for valve closing will have the following form:

$$P + G + D = P' + R + B \ldots\ldots\ldots\ldots\ldots [5]$$

or

$$P + G + D - P' - R - B = 0 \ldots\ldots\ldots\ldots [6]$$

This equation can be constructively satisfied by proper appliances, and with it can be satisfied the conditions of shock free valve closing; viz., that the sum of all forces or works at the end of the valve motion be equal to zero. How this is done may be seen from Figs. A and B.

The opening of the valve in Fig. A lags behind the dead point of the piston by the time $\triangle t$; the valve closing lags behind the other dead point of the piston by the time $\triangle t_1$. In accordance with this, the cross-sectioned area representing the work of the stream impact is reduced by the little black area having the abscissa $\triangle t$. Because of the reversed flow of the liquid, there occurs on the left side a negative working of the stream impact, which is limited by the abscissa $\triangle t_1$ and by a part of the curve $E_2$. The curve $E_2$ is the same as the curve $E_1$, but, in accordance with its negative sign, is curved downward. In the case of pumps handling liquids, the above applies to both valves.

In compressors, air pumps and blowers, the suction valve indicated in the lower part of Fig. B opens not at the point $b$, but at $b_1$, lagging by the time $\triangle t$, and the work of the stream impact is reduced by the amount of the black strip. The valve closing, lags behind the dead point of the piston by the time $\triangle t_1$. The negative working of the stream impact is limited by the abscissa $\triangle t_1$ and the curve $E_2$ and is marked in black.

The opening of the pressure valve occurs not at the point $c$, but lags behind it at the point $c_1$; the working of the stream impact is reduced by the black strip (Fig. B, upper part). The valve closing occurs behind the dead point of the piston and the negative work is marked in black (*Betrachtungen über die Bewegung der "freigängigen" Ventile*, O. Klepal, *Die Fördertechnik*, vol. 8, no. 19, p. 145, October 1, 1915, 6 pp., 8 figs., *td*).

[1] This refers apparently to pumps handling liquids.

### The Holding Power of Nails

The subject of the holding power of nails in wood, and especially in hard wood, does not appear to have been sufficiently investigated and the information contained in the present abstract may therefore be of particular interest.

As the writer states, a glance at the interior of any coasting boat will show that although every nail is clinched and a length of 3 in. is allowed for that purpose, while the spread of the head barely amounts to 1 in., the waste of iron in nails alone cannot be less than from 20 to 25 per cent.

A nail holds itself in place in two ways; by friction of its sides against the wood, and when clinched, by the resistance of the clinch, which resembles a second and smaller head. Square nails are usually tapered on two sides and straight on the other two sides. The tapered sides should bear against the end grain of the wood, crushing it gradually as the nail enters. All woods, when soaked in water or when green, may be nailed with less risk of splitting than when they are dry, but there are limits to the depth that a long nail may be driven into any wood before it begins to bend. When a nail begins to bend, it shows that a hole must be made beforehand. The object of the hole is to reduce the friction so as to allow the nail to be driven without bending, but if made too large, the holding power of the nail will be reduced and clinching will be a very imperfect remedy.

If many nails of one size have to be driven, as in boat building, it is advisable to experiment on a piece of wood of the necessary thickness in order to find out the right size of hole that will avoid splitting the wood or bending the nail. When wire nails of a large size are to be clinched, they should be softened at the point by heating to redness. A wire nail is hard drawn to enable it to be driven without bending in soft woods, but it does not clinch well for this reason and therefore needs softening. To ascertain the holding power of a nail, it may be driven into an upright post, leaving the head projecting just enough to be seized by a

nail-puller. This instrument is then attached and weights added to the outer edge until the nail begins to move.

Nails that have rusted after being driven have an increased holding power, but if rusted before use they tend to make a slightly larger hole than a smooth nail. In cases where clinching would be liable to split the wood, nails may be cut and riveted over a small washer, which makes a strong and durable joint. There is also a way of clinching a nail within the wood. The point is filed away on one side to a wedge shape and then bent over the filed part until the point is level with the side of the nail. The hole is drilled to the size of the nail which is inserted with the filed surface parallel to the grain of the wood. When driven, the point takes the form of a hook and has a strong hold on the wood. The point of this nail should be heated and softened so as to facilitate the turning of the point.

Nails driven in wood that is exposed to alternate wetting and drying are liable in time to work loose because the wetting swells the wood and increases its dimensions around the nail, and as the nail is non-elastic itself, a compression is formed at the point of the nail to the amount of the swelling of the wood. When the timber dries again, the nail does not return to its original place, and if tapered, it tends to draw outward every time the wood is wet and dried. (*The Canadian Engineer,* vol. 29, no. 18, p. 519, October 28, 1915, abstract from the *Indian Textile Journal.*)

### Steam Engineering

#### Dry Back Marine Boiler, Arthur C. Meyers

Description of an improved marine boiler designed to obtain better circulation.

To accomplish this, a tube sheet was fitted in the rear end of the furnace and the furnace connected with the combustion chamber by 4 in. tubes. It was expected that this would set up a more rapid circulation than was possible by the usual method of attaching the furnace directly to the combustion chamber. Short tests were made to determine the capacity of the boiler, but the shell was not insulated and the feed water was very low in temperature (45 deg. fahr.). The data of tests are given in Table 1. Natural draft was used, the stack being 40 ft. high and 18 in. in diameter (*International Marine Engineering,* vol. 20, no. 11, p. 511, November, 1915, 2 pp., 1 fig., *de*).

TABLE 1. TEST OF AN IMPROVED MARINE BOILER

| | |
|---|---|
| Duration of test | 1 hr. 34 m. 35 s. |
| Grate Surface | $8^5/_9$ sq. ft. |
| Heating Surface: | |
| Furnace crown | 21 sq. ft. |
| 19 4-inch tubes 12 in. long | 18.62 sq. ft. |
| 41 3-inch tubes 6 ft. 8 in. long | 199.52 sq. ft. |
| Back tube sheet (effective) | 3.65 sq. ft. |
| Total Heating Surface | 242.79 sq. ft. |
| Ratio H. S. ÷ G. S | 28.39 |
| Average Steam Pressure by gage | 95.05 lbs. |
| Average Steam Pressure Absolute | 109.75 lbs. |
| Average temperature of Feed Water | 45 deg. fahr. |
| Total water fed to boiler during test | 1,845 lbs. |
| Total water fed to boiler per hour | 1,165 lbs. |
| Quality of steam, per cent | 97 |
| Water evaporated per hr., corrected for quality | 1.130 lbs. |

Factor of evaporation, $\frac{(H - t + 32)}{966.1} = 1.212$

Where H = total heat of steam at 109.75 lb. absolute = 1,183.9.
t = average temperature of feed = 45 deg. fahr.
Water evaporated from and at 212 deg. fahr. = 1,130 × 1.212 = 1,369.56.

#### Tests of a 300 H.P. Superheated Steam Locomobile

The article describes tests of a 300 h.p. superheated steam locomobile plant made, first, at acceptance and then, after the plant had been in operation for two years.

The plant comprises a double-expansion superheated steam locomobile with Lentz valve gear, condensation by water injection, multitubular boiler with withdrawable fire-box and flues, and superheater built in in the smoke chamber. It has automatic powdered coal firing, operated by a small motor. The plant is used to drive a 550 volt polyphase generator of 240 kw. output, at 600 r.p.m. In order to avoid long interruptions during boiler cleaning, there has been provided a complete reserve set of fire box and flues. In addition to the measuring apparatus prescribed by law, the boiler is equipped with a superheater thermometer and differential draft gage. The draft is created by a suction fan driven by an electric motor and provided with a governor which regulates the output of the boiler in accordance with the power demand. The engine is governed by a Lentz eccentric governor placed on the crank shaft. The piston rods are provided with Lentz metal packing.

The article describes fully the method of making tests and in several tables reports the results obtained. The following are the most important data:

The steam consumption at rated output was 4.59 kg. (say 10 lb.) per h.p. While the engine is rated at 300 effective h.p., it carried during the test, in a satisfactory manner, a peak load of 429 effective h.p. for 10 to 12 minutes and the steam pressure could still be maintained with powdered coal firing. The mechanical efficiency of the steam engine was found to average over 94 per cent, while the efficiency of the boiler plant and superheater together was established by the first test to be around 80 per cent.

During the preceding two years, the locomobile was in operation on an average of 14 hours per day. The coal consumption established during this continuous operation was found to be, including all losses of firing up and removing clinker, on an average of 0.88 kg. (1.9 lb.) per effective h.p-hr. in the daytime and 1.06 kg. (2.4 lb.) at night. It must be remembered that the fuel was cheap washed powdered coal of a low heating value which makes these results appear quite favorable. It was found that when the load on the locomobile increased, the coal consumption decreased relatively; on the other hand, when in the period of August to November, 1911, because of lack of water for injection, a very low vacuum was maintained, the coal consumption went up quite noticeably. In this connection a rather curious thing was observed, viz., that the powdered coal, contrary to the case with lump coal, increased in heating value from 5 to 8 per cent with storage. (*Leistungsergebnisse bei der Abnahme und in der Praxis einer 300 PS Heissdampf-Lokomobil-Anlage, Zeits. des Oesterreichischen Ingenieur-und Architekten-Vereines,* vol. 67, no. 38, and 39, pp. 486 and 502, September 17 and 24, 1915, 8 pp., *ed*).

#### Boiler Inspection on Private Railroads in Russia, B. B. Sooshinski

In 1912, the technical inspection of steam boilers on private railroads was given by the government under the charge of an organization called the Society of Private Railroads for the Inspection of Steam Boilers.

Twenty-five railroads, practically the entire private railroad system of Russia, are in this Society. The latter not only inspects the boiler, but has charge of a large part of the research work connected with the boiler proper, or firing. An extensive program of boiler testing is under consideration. One of the most important elements of success of this Society is that being in the hands of private

companies, it is not deeply involved with red tape (*Nadzor za paravymi kotlami chastnykh jelcznykh dorog,* B. B. Sooshinski, *Bulletin of the Permanent Committee of the Consulting Conferences of the Agents of Various Branches of Service on Russian Railroads* (in Russian), vol. 14, no. 8, p. 872, August 1915, 4 pp., *gs*).

### Strength of Materials and Materials of Construction

Behavior of Iron and Steel Under Compression in Tests, H. Monden

The article describes a series of tests of considerable interest made in order to determine how the shape of the test piece affects the results of the test. Among other things, the tests are of interest because in them an attempt was made to test iron and steel under compression. In addition to this, there were carried out tests on hardness. The following results have been obtained:

1. As regards the influence of the shape of the test piece in compression tests; the tension at the yield point — $\sigma$ is not affected by the shape of the test piece within the limits investigated in so far as its magnitude is concerned, but is affected in so far as its visibility is concerned. The elongation — $\varepsilon$ is increased with the increase of the ratio of $h/\sqrt{f}$ within the limits applied from [(0.5) to 3] and with equal ratio of $h/\sqrt{f}$ they are smaller when the cross section is circular than when the cross section is square.

2. As regards alternating relations, it has been found that the tension at the yield point in compassion is equal to that in tension, or $\sigma_{+s} = \sigma_{-s}$ The stress at the yield point $\sigma_s$ is materially affected by the size of the grain of the material, in such a way that, all other conditions being equal, the stress decreases with an increase in the size of the grain.

The linear relation established by Kürth, for the improvement of the yield point and Brinell hardness by the cold working, viz.: $\sigma_s = 1/c\ (H - H_o)$ holds for the types of wrought iron and steel used for technical purposes in that the constant $1/c$ remains of the same magnitude for all kinds of wrought iron, while the constant $H_o$ is a function of the size of grain in that it decreases with the increase of the latter (*Ueber das Verhalten mehrerer Eisen- und Stahlsorten beim Druckversuch,* Herbert Monden, *Stahl und Eisen,* vol. 35, nos. 40 and 41, pp. 1022 and 1052, October 7 and 14, 1915, 11 pp., 10 figs., *eA*).

Binary Alloys of Aluminum, H. Schirmeister

The article describes an interesting series of tests on binary alloys of aluminum.

In so far as good rolling and normal annealing is concerned, zinc is probably the metal which produces by far the greatest improvement in the mechanical properties of aluminum, although the strongest alloys, containing from 25 per cent to 28 per cent of zinc, depart from the very low specific weight. Further, the higher percentages of zinc materially lower the melting point and strongly affect the resistance of the alloy to weathering conditions. The next strongest alloy is that of aluminum with 5 to 6 per cent magnesium, but this alloy has only a low resistance to chemical action. In the third place stand copper alloys, which attain the greatest mechanical strength when the addition of copper is about 3 per cent. It resists atmospheric reactions very well and has still quite a high melting point. From a practical point of view, therefore, this system is the most available and the most widely used. Next to this come the alloys of aluminum with silicon, nickel, cobalt and iron. Of the rare metals only chromium produces a really material improvement, while manganese, vanadium and molybdenum are also of certain advantage. With all other metals the advantage obtained is so insignificant that it is hardly worth while to add them at all.

The methods of production and machining of the alloys have also been investigated. With proper methods of melting, the difference between the results obtained with the use of graphite or clay crucibles, as well as the various temperatures of pouring, are not substantial. On the other hand, a rapid rolling at high temperatures produces, as a rule, considerable improvement in the elongation obtained, while a cold working which is as thorough as possible, produces a not inconsiderable improvement in tensile strength even after annealing. The resistance of the alloy to chemical actions appears to be somewhat affected by the mechanical and heat treatment of the metal, but it depends essentially on the chemical composition of the alloy. It can be determined with certainty only by thorough tests of long duration made under conditions approximating those of the actual working of the alloy.

As far as casting in molds is concerned, shrinking has also a great importance, since the less is the tendency of the alloy to shrink, the better adapted it is for casting. In general, the author comes to the conclusion that material for casting must be more highly alloyed than that for rolling.

Finally, he found for all aluminum alloys, without exception, that additions of very small amounts, such as tenths and hundredths of one per cent, did not affect either the mechanical or chemical properties of aluminum. This is only natural, since even what is known in the trade as pure aluminum contains usually about 1 per cent or more of "impurities," which are nothing but alloyed elements (*Zur Kenntniss der binären Aluminiumlegierungen,* Hermann Schirmeister, *Stahl und Eisen,* vol. 35, nos. 34 and 39, pp. 873 and 996, August 26 and September 30, 1915, *e*).

### Miscellanea

Large Laundry for Handling Ship Washing, Wm. Scholz

Description of the large laundry installed by the Hamburg-America line, at Kuhwärder Harbor (leased by that Company).

The necessity for such a laundry was created just before the war by the construction of ships of the *Imperator* type, having a passenger list of more than 4500 and making the trip between Hamburg and New York in from five to six days. During such a trip, both ways, up to 30,000 kg. (say, 65,000 lb.) of wash accumulates, and this has to be taken care of in a very short period of time, between the arrival and departure of the steamer at Hamburg, unless a very large extra stock of linens be kept. To this was added the fact that sending the wash to a private laundry inland involved a lot of troublesome custom formalities. It was decided by the company, therefore, to install a plant of its own which would take care not only of the washing proper, but also the removal of spots and the repair of the linen. That there would be sufficient business for the plant was shown by the fact that it would be called upon to take care of the washing for more than 200 seagoing vessels.

In view of the fact that ships of the *Imperator* type can-

not come in close to the shore in the harbor selected for the site of the laundry, the washing has to be delivered by lighter, which required particular installations to make the handling of it, in and out of the lighters, convenient. For the loading and unloading at shore, a special loading bridge of reinforced concrete, with the exception of the roof, was built. The laundry delivered from the land side is taken in at the east wing of the building and delivered directly to the reception and weighing room. That taken in from the water side is delivered in sacks, weighing 30 to 40 kg. (66 to 88 lb.), to the loading platform in batches of 15 to 20 sacks each, by means of a portable electrically driven loading crane. From the platform, it is delivered inside the building, where it is sorted and weighed.

The washing machinery is not described in great detail; some features, however, are of interest. In order to reduce the number of attendants at the steam mangles, a special device designed by the author of the article, was introduced for handling the washing put in; this device is particularly convenient for mangles handling large numbers of pieces of the same type, such as handkerchiefs, napkins, etc. (In this connection it is mentioned that a steamer of the *Imperator* type brings, after a return trip, something like 40,000 napkins).

The usual output of the laundry for a nine-hour working day, is 8000 to 10,000 kg (17,600 to 22,000 lb.) of fully washed and packed linen. In order to prevent deterioration of large and valuable linen, each piece, which during the sorting process is found to be injured, however slightly, is delivered immediately to a repair shop, equipped at present with 20 electrically driven sewing machines.

The washing machines, centrifugals and steam mangles, are illustrated in the article. The water supply and ventilating systems are briefly described (*Die Grosswäscherei der Hamburg-Amerika-Linie in Hamburg-Kuhwärder,* Dr. Wm. Scholz, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, no. 40, p. 815, October 2, 1915, 7 pp., 17 figs., *d*).

# ENGINEERING SOCIETIES

## AMERICAN SOCIETY OF CIVIL ENGINEERS

*Proceedings, vol. 41, no. 8, October 1915, New York City.*

The Automatic Volumeter, E. G. Hopson

The paper describes an apparatus intended to gage the flow of fluids by the collection of a proportionate part of the flow or its equivalent, in a small vessel where it can be readily measured at any time. The apparatus is arranged in such a way that the pressure head under which the discharge into the collecting vessel takes place, is at all times equivalent to, or a constant ratio of, the velocity head of the liquid or gas being measured. The name volumeter is somewhat of a misnomer since actually it is the velocity or pressure due to velocity that is its operating force.

The volumeter operates by the velocity head of the fluid which is being measured. Not only is velocity head communicated, but a very small proportion of the actual flow is diverted into the apparatus, though this proportion is so small and the velocity of flow in the diverting pipe so insignificant that there are no appreciable losses of head by friction in the pipe to disturb the basic plan of operation by velocity head. A return pipe from the volumeter to the stream carries away the surplus liquid created by the influent flow. The apparatus may be attached to a pipe with communication through a Pitot tube, or at submerged orifices, or on a short pipe or box flume of varying cross-section, or in several other ways. The method must only be consistent and be such that the head communicated to the volumeter is a constant factor of the velocity head, which later is the essential condition.

The most difficult feature of the apparatus to work out was an arrangement whereby the head under which the interior jet operates is kept identical with or a constant factor of the velocity head of the stream. It is necessary for the apparatus to be absolutely automatic and its response to the most minute changes of head to be immediate and of the most delicate sensitiveness. It works in the following manner: The influent entering the upper part of the lower vessel (Fig. 5) creates a pressure at its point of entry equal to the sum of the static and velocity heads of the entering water, the frictional losses in the influent pipe and orifice being negligible, due to their great size and the very low velocities in them. The lighter medium (liquid or gas) contained in the lower vessel is thus put under pressure. The upper vessel is connected with the flowing water in such a manner that only the static head is communicated to it. The flow through the small orifice connecting the two vessels, therefore, is for all practical purposes that due to the velocity head or a constant factor of the velocity head only.

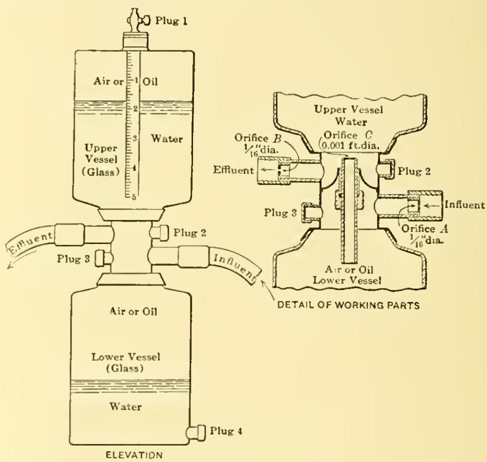


Fig. 5 Automatic Volumeter

The operating details are shown in the figure. The influent enters the lower vessel or container at its upper part through an orifice at *A*. The pressure communicated is due to the static head of the water being measured plus the velocity head due to the rate of flow. This pressure is communicated to the medium (oil, air or whatever may be used) in the lower vessel and in turn is transmitted through the medium to the lower side of the point of connection with the upper vessel at the orifice *C*. The water in the effluent pipe is only under the pressure due to the static head of the stream being measured. This pressure is communicated directly through the water in the lower part of the upper vessel down to the upper side of the orifice, *C*. When there is no velocity, the static head of the stream is communicated to both the upper and lower sides of the orifice, *C*, and there

is no movement. Whenever there is velocity the corresponding head is at once communicated to the lower side of the orifice $C$; the balance of forces is overthrown and a movement is started proportioned to $\sqrt{2g}$ multiplied by the square root of the velocity head less what head is required to overcome the various frictional resistances.

In order to work out this device, the coefficient of flow through very small orifices had to be established and experiments along these lines revealed totally unexpected conditions. It has been necessary to deal here with flow through orifices not exceeding 0.001 to 0.004 ft. in diameter, and apparently with these small openings, the ordinary laws of flow did not apply with the lower heads. Another marked difference between results obtained with these small orifices and with the larger ones is that apparently the former have distinctly greater coefficients under certain heads than the latter.

In addition to experiments with water, runs were made using oil. It was necessary to find an oil having a viscosity which did not change very materially under changes of temperature, such as would be encountered in a water measuring device under working conditions. The oils most nearly approaching these conditions were kerosene, a petroleum product known commercially as white neutral oil, and another petroleum product known as glymol (a thick clear oil, used generally for medicinal and surgical purposes). From experiments, it was found that a very appreciable force was necessary to break the seal of surface tension and induce a flow between the different media through the small orifices required on this apparatus. A study of the curves of coefficients of flow seems to indicate clearly that the reduction of the coefficient with the small orifices under low heads is due largely to some obscure retarding force, such as surface tension, which actually absorbed a portion of the operating or velocity head applies and is, to a considerable extent, a constant in itself.

The principal sources of error in this device are temperature changes affecting the specific gravity of the measuring medium or its bulk. Changes in the air density will also influence the results to a small extent. Some of the causes of error can be avoided or obviated. Others are inherent but tend to a considerable extent to balance and neutralize each other. The apparatus must be set by one who understands the principles of its operation, but its further operation is so simple and automatic that any ditch rider of average intelligence will be able to reset and read it each day or whenever necessary (17 pp., 9 fig., *ed*).

### AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

*Journal, vol. 22, no. 1, October, 1915, New York City.*



TESTS ON THE RECIRCULATION OF WASHED AIR, PROF. G. L. LARSON

Recent investigations have shown that what is known as bad air is caused by neither depletion of the amount of oxygen present nor excess of carbon dioxide, and symptoms of discomfort in a poorly ventilated place are due mainly to the physical conditions of the air with respect to temperature, humidity and movement, and not to its chemical properties. The present paper describes tests (Wisconsin High School), undertaken in order to ascertain the advisability of installing similar systems in the future buildings of the University of Wisconsin.

The high school building is heated partly by direct radiation and partly by indirect, the system being of the one-pipe direct steam type throughout. Ventilation of the building is provided by a blast fan discharging through ducts on the ceiling of the basement that rise to the rooms to be ventilated and enter the rooms near the ceiling; special systems of ventilation are used for the toilet rooms and the chemical laboratory. The paper describes fully the apparatus and methods used.

Considerable difficulty was experienced in determining the true volume of air entering the rooms. Readings were taken at the duct leading to the gymnasium. First a series of readings were taken at the register and then the register was removed and another set of readings taken, holding the anemometer horizontally in the vertical duct leading to the room. The readings at the register showed an average of 482 ft. per minute and those in the duct showed an average of 810 ft. per minute. The registers are unusually heavy and the net area of the particular size in the gymnasium is only 96 per cent of the area of the vertical duct leading to the room. Therefore the velocity through the register should check very closely with the velocity in the duct, which was, however, very far from being the case. These and other tests showed conclusively that the register deflected air currents inside and gave velocity values which were very much lower than the actual values, so that the readings taken with the anemometer placed against the register are absolutely unreliable.

The author comes to the following general conclusions:

1. The tests show that it is both unnecessary and uneconomical to supply large volumes of air to obtain good ventilation.

2. That 15 cu. ft. of air per student would be ample, providing it enters the room at a fairly high velocity and carries the proper amount of moisture.

3. With humidity ranging from 50 to 70 per cent, the occupants of the rooms are perfectly comfortable at a temperature of 65 deg. or even less.

4. With humidity of about 60 per cent, the air can enter the rooms at a temperature of 60 deg. without creating any discomfort; in fact it seems to give life to the air and aids in the efficiency of ventilation.

5. Carbon dioxide content as high as 20 parts in 10,000 does not have a bad effect upon the ventilation.

6. Ventilation by recirculation is both efficient and economical. At the end of a year's run the teachers are almost unanimous in their praise of the system.

7. With a recirculating system such as this, it requires from 40 to 50 per cent less steam to heat the building, while the fan is in operation, than would be required if the air was drawn from outdoors for the same length of time.

8. Air movement keeps the temperature uniform in various parts of the room and decreases the amount of steam

required for heating. The tests show a minimum saving of about 8 per cent due to this air movement; this would be true whether the system is a recirculating one or otherwise.

9. The air washer absorbs a considerable amount of the carbon dioxide contained in the air passing through it.

10. The air washer is apparently quite efficient as a dust remover but it does not remove bacteria from the air when the washer water is recirculated. The tests show that it actually supplies bacteria to the air under such conditions.

11. In spite of the poor showing of the washer, the air entering the rooms carries no more bacteria than outside air when the relative velocities in which the plates were exposed are taken into account.

Further tests are being planned (41 pp., 11 figs., *de*).

## CANADIAN SOCIETY OF CIVIL ENGINEERS

*Transactions, vol. 29, part 1, January to June 1915, Montreal.*

Movable Dams, H. B. Muckleston
Lethbridge Sewage Disposal Works, A. C. D. Blanchard
Jordan River Power Development, C. A. Lee
Edmonton's Tunnel Sewer System, A. J. Latornell
Tests on the Shearing Resistance of Reinforced Concrete Beams, E. Brown, H. M. MacKay, and C. M. Morssen (abstracted)

Tests on the Shearing Resistance of Reinforced Concrete Beams, E. Brown, H. M. MacKay and C. M. Morssen.

The paper describes the results of tests carried out by the authors in connection with the work of a committee of the Society, on concrete and reinforced concrete. The authors state that the formulae derived (for the allowable shearing stress intensities and for computation of stirrups), are admittedly inadequate as a representation of the actual conditions in a beam, but, used in conjunction with experimental data as a means of fixing allowable unit stresses, they may serve as a satisfactory means of estimating the amount and disposition of steel required to reinforce the beams adequately against shears.

Four distinct lines of experimentation were followed, to determine the behavior of beams reinforced with (*a*) straight rods only on the tension side; (*b*) combination of straight and bent rods, the latter assisting in carrying the tension due to shearing; (*c*) straight rods as in (*a*) assisted by vertical stirrups of different spacing, and (*d*) a combination of straight and bent rods as in (*b*) assisted by vertical stirrups of different spacing.

It was found, broadly speaking, that the beams in which some of the main reinforcement is bent up diagonally deflect less than corresponding beams in which all of the main reinforcement is straight. This is a definite action of the diagonal rods. The effects of different stirrup spacings on the deflections are irregular. In many cases, the cracking of beams was checked noticeably by the stirrups and marked increases of ultimate strength resulted by adding stirrups to beams having straight rods only as tension reinforcement. Sometimes a crack would extend directly through the body of a beam so as to enable an observer to see through it, but the stirrups held the two elements of the beam and prevented collapse.

The general effect of stirrups was to raise the ultimate strength very noticeably and when spaced 4 in. apart, shearing failure was eliminated. Shear failure may also be obviated by bending up some of the tension reinforcements in a diagonal direction. The diagonal bending up of rods also greatly increases the ultimate strength and the addition of stirrups to the beams having such diagonal rods, affects the manner of failure rather than the load at failure.

The tests were carried out mainly with reference to the clause of the specification adopted by the Canadian Society of Civil Engineers (clause 28) (20 pp., 2 figs., *e*).

## COLLEGE OF ENGINEERING, KYOTO IMPERIAL UNIVERSITY

*Memoirs, vol. 1, no. 4, August 1915, Kyoto, Japan.*

On Leonard Control applied to Mine Hoists, Risaburō Torikai.

The paper considers the load diagram, the gradual rating and the theoretical durations of acceleration and retardation of a direct current mine hoist motor controlled by the Leonard system, without entering upon discussion of the equalizing apparatus. It is to a certain extent an extension of the paper by Wilfred Sykes on large electric hoist plants in the Proceedings of the American Institute of Electrical Engineers, Vol. 29, Part I, 1910.

The paper gives the general equations of the resisting moment of hoist as well as equations from which may be found the economical relation between acceleration and retardation. An equation is given from which may be determined, though with some difficulty, the capacity of the hoist motor, taking iron losses into account. The subject is treated mathematically. (33 pp., 3 figs. *m*).

## ENGINEERING SOCIETIES OF PURDUE UNIVERSITY

*The Purdue Engineering Review, vol. 15, no. 8, 1915*

Flood Protection in Indiana, Professor W. K. Hatt
Tests of Standard and Clasp Brake Rigging for Passenger Train Service, E. F. Lickey (abstracted)
Notes on the Construction of a 48-inch Re-inforced Concrete Sewer, Albert A. Chenoweth
Rope Transmission, E. M. Carver

Tests of Standard and Clasp Brake Rigging for Passenger Train Service, E. F. Lickey

The paper is mainly an extract from a report submitted to the officials of the Lake Shore and Michigan Southern Railway by the engineers who carried out these tests.

Several years ago, the L. S. and M. S. Railway had, in common with other roads, a great deal of trouble with skid flat wheels, caused by the heavy braking pressures necessary on account of the increased weight of equipment and aided by the cold winter weather and frosty rails. The clasp type of brake rigging was proposed as a means of overcoming the trouble and in order to determine what advantage, if any, the clasp brake arrangement possessed over the standard foundation brake rigging, a series of tests were made near Toledo, O., by a group of engineers representing the Westinghouse Air Brake Company and the L. S. and M. S. Ry. The track was equipped with a chronograph and the necessary circuit breakers. The necessary speeds were obtained by running the train back several miles distance, depending upon the speed desired and then making the run toward the tripping point; at the trip, the engine was cut loose from the train and the latter was braked by making the desired brake pipe reduction. The speed was judged from a Boyer recorder on the engine and by experience. Brake cylinder pressures were recorded by indicators attached to them.

Under like conditions of standing piston travel and brake pipe pressure, the clasp brake cars stopped slightly shorter than the standard brake cars. It was found that with approximately 150 per cent nominal emergency braking power on the clasp brake cars and 170 per cent nominal emergency braking power on the standard braking cars, the difference in running piston travel with the two equipments will be such that the actual percentage of braking power realized will produce practically the same stop with each type of rigging.

The stops with the three clasp brake cars vary through a considerably narrower range than that for the three standard brake cars with the same percentage of braking power, which indicates that the clasp brake insures a greater uniformity of brake action. A single car emergency test made to find out if there was any greater variation in rates of retardation on individual cars with the standard brake than there was on cars with the clasp brake, indicated that on the basis of the same amount of braking power, the individual cars vary but little and approximately the same amount for both types of rigging.

Comparative tests of standard brake cars with and without emergency reservoirs have shown that there was an average increase of about 166 ft. in the length of stop when the emergency reservoirs were cut out, which is, however, only the difference between the best and the poorest stops by the standard brake cars with the emergency reservoirs cut in. Practically the same relation between the emergency stops with emergency reservoirs in and out was found to exist with the clasp brake cars as with the standard brake cars.

With the standard brake rigging, it was observed that the high pressure exerted by the single shoe on one side of the wheel, tilted the axle bearing brasses sufficiently to lift one side of the brass a considerable distance away from the journal, so that a wide space was opened for waste to be caught between the brass and the journal when the brake was released; these effects were noted in service applications of the brake as well as in emergency applications. With the clasp brake arrangement, however, nothing of this kind was noted.

No record of the amount of brake shoe wear, by weighing of the shoes, was taken. It was noted, however, that the temperature of both wheels and brake shoes with clasp brake cars was uniformly much lower than with the standard brake rigging. On the whole, the conclusion was arrived at that the clasp type of brake was the proper design for use on heavy passenger equipment (7 pp., 2 figs., *e*).

## SOCIETY OF CHEMICAL INDUSTRY

*Journal, vol. 34, no. 19, October 15, 1915, London.*

Vulcanization Experiments on Plantation Para Rubber. The Cause of Variability, B. J. Eaton and J. Grantham.

The writers call attention to the controversial statements made during the last two or three years, concerning variability in plantation Para rubber. While some manufacturers claimed that the variation is considerable, even in the case of "First latex" rubber when compared with fine hard Para, or first grade of wild Para rubber, leading rubber technologists maintain that the best grades of plantation Para rubber, especially sheet, are superior to fine hard Para. The writers, on the basis of an extensive series of experiments made at the testing laboratories of the Department of Agriculture, Federated Malay States, claim that both opinions may be taken as correct and are not necessarily contradictory.

They come to the following conclusions:

(1) Considerable variation occurs in plantation Para rubbers, even in the case of "First latex," both among rubbers from the same estate and from different estates.

(2) This variation is connected principally with the behavior of the rubber on vulcanization, i. e., its rate of cure and not in respect to its strength, elasticity, and general mechanical properties, especially in the case of properly prepared "first latex" samples.

(3) If the rate of cure be known or ascertained under specific conditions, vulcanized rubber having similar chemical properties can be made from all good samples of "first latex" rubbers.

(4) A difference in mechanical properties does exist, even among so-called first quality rubbers, but these differences are greater between high and low grade plantation rubbers; some rubbers never attain the maximum mechanical properties reached by others, whatever period of cure is adapted. These differences, in the case of the "first latex" rubbers, however, are not so important to the manufacturer as the differences in rate of cure, and are not of the same order. Indeed, the remarkable uniformity in type of curve points to the fact that the variation of mechanical properties in our samples, at any rate, is of an accidental nature, for at points below the breaking point the mechanical properties are the same.

(5) The rate of cure is due to the presence of some non-caoutchouc substance in the latex, possibly protein or some other organic constituent, or to some degradation product derived from these substances, which acts as a catalyst, and accelerates the rate of cure.

(6) This substance may be already present in the latex, and its amount in the raw rubber determined by the mode of preparation and coagulation, or it may be subsequently formed in the latex by decomposition and taken up by the rubber in variable quantity, according to mode of preparation, or, alternatively, it may be formed in the coagulum in variable quantity, depending on the amount of serum (or moisture) left in the coagulum or the presence of preservatives which hinder or prevent its formation. The alternative theories await investigation.

(7) Smoking, removal of excessive serum in the washing and machining processes, and preservatives are among the artificial factors which either hinder the formation of this substance, or, if it already exists in the prepared rubber, partially destroy it.

(8) The catalytic substance is probably not affected greatly by the heat, since in the process of mixing and vulcanization, the rubber is subjected to relatively high temperature. Whether heat destroys it or prevents its formation in the latex or freshly coagulated rubber awaits investigation.

(9) The rate of cure of a rubber under specific conditions is not indicated in any way by the apparent mechanical or any other apparent properties of the raw material, hence the worthlessness of the present methods of valuation of rubber.

(10) *Caeteris paribus,* a manufacturer probably prefers a rapidly curing rubber, since it represents economy in heat, labor, and time costs, and secondly, a rubber which cures

rapidly is said to have better keeping qualities after vulcanization.

(11) Uniformity between "first latex" rubbers from different estates will probably be very difficult of attainment with present methods, owing to the number of factors involved, but should not be so difficult among such rubbers from the same estates.

(12) Two alternatives are suggested: (a) The issue of certificates giving correct rate of cure and mechanical properties at this cure; (b) The attainment of more uniformity by the method suggested in this paper and elsewhere, in which rubber from latex collected during a series of days forms part of one ball or block, which may be described as the method of averages (11 pp., 5 figs., *epA*).

## UNIVERSITY OF ILLINOIS

*Bulletin, vol. 12, no. 47, July 26, 1915, Urbana, Ill.*

Influence of Temperature on the Strength of Concrete, A. B. McDaniel

The purpose of the bulletin is to furnish information based on experiments to determine the influence of temperature on the attainment of strength in concrete. The author comes to the following general conclusions:

*First.* Under uniform temperature conditions, there was an increase of strength with age within the limits of the tests. For any temperature the rate of increase decreases with the age of the specimen; and this rate of increase is less correspondingly at the lower temperature conditions. For the specimens tested, under normal hardening temperature conditions of from 60 to 70 deg. fahr., the compressive strength of the concrete subjected to a uniform temperature at the ages of 7, 14 and 21 days may be taken as approximately 50 per cent, 75 per cent and 90 per cent of the strength at twenty-eight days, respectively. For lower temperatures the percentage values are less, and for higher temperatures the percentages are higher. The relation between the percentage values at the age of 7, 14, 21 and 28 days is nearly the same for temperature conditions from 30 deg. to 70 deg. fahr. However, the values for the lower temperatures should be used with caution.

*Second.* Concrete which is maintained at a temperature of 60 deg. to 70 deg. fahr. will at the age of one week have practically double the strength of the same material which is kept at a temperature of 32 deg. to 40 deg. fahr.

*Third.* Figs 6A and B may be used to determine the representative strength of concrete similar to that used in these tests, for various temperature conditions and for ages up to 28 days. These diagrams may be used with a fair degree of approximation to ascertain the relative strengths which concrete of ordinary practice may be expected to attain at the different temperatures. It should be noted that generally in this investigation the specimens were stored under temperatures which were nearly uniform during the whole storage period. The tests summarized in Fig. A and B cover a wide range of temperature conditions, the average temperature varying from 20.4 deg. fahr. to 90.6 deg. fahr., and are fairly consistent; and hence it is believed these values are sufficiently accurate to furnish suggestive information which may be useful in determining the time when forms may be removed and loads applied. The results accord with the well-known effect of freezing and thawing upon green concrete (24 pp., 15 figs., *c*).

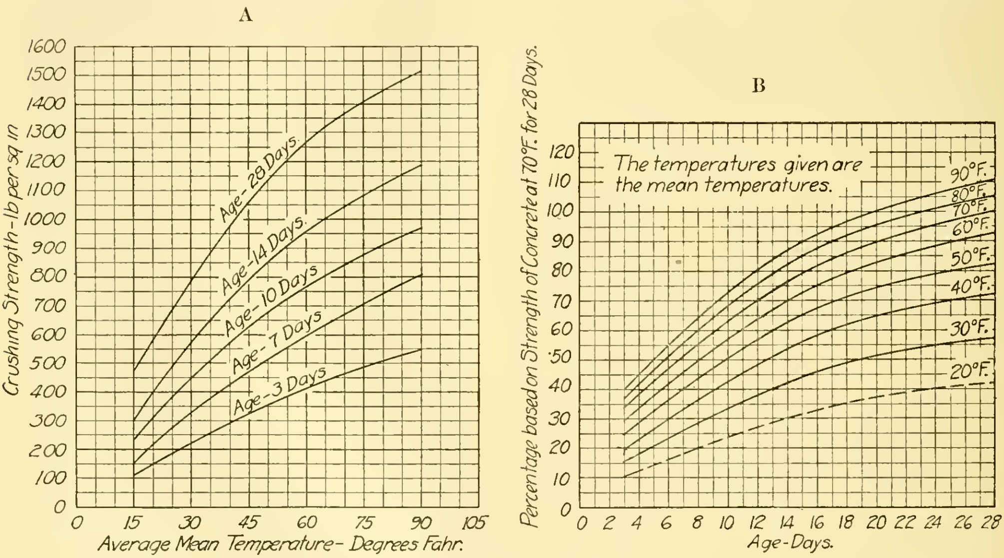



Fig. 6 A, Relation of Strength to Temperature for Different Ages; B, Percentages of Strength for Different Temperatures

### CLASSIFICATION OF ARTICLES

The various articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

## MEETINGS

### CINCINNATI, OCTOBER 21

The regular October meeting of the Cincinnati Section of the American Society of Mechanical Engineers was held as a joint meeting with the Engineers' Club of Cincinnati, on October 21. The speaker was O. Monnett, of the American Radiator Company, formerly Associate Editor of Power, and Chief Smoke Inspector of the city of Chicago. His remarks were based upon a very fine collection of lantern slides which had been accumulated during his efforts to eliminate smoke in Chicago. Mr. Monnett began by describing and showing the dutch oven construction for hand-fired furnaces under boilers. He reviewed the experiences with this form of setting before it was abandoned, and showed that its failure to burn coal smokelessly, or nearly smokelessly, was due to a rapid distillation of the volatile matter in the coal from the intense heat of the top arch. The speaker then took up in detail the various furnaces for hand firing that were developed in Chicago until the latest form of double arch bridge wall furnace was devised. The speaker mentioned the fact that this furnace had been quite successful in Chicago, and that it had been adopted by the city of Cincinnati for burning of high volatile fuels.

Mr. Monnett said that the chief factors in smokeless combustion are temperature, mixture, time, and oxygen. In other words, that there must be present sufficient oxygen to burn volatile hydrocarbons, that there must be an intimate mixture of the oxygen and hydrocarbons, that there must be sufficient time for the burning before the comparatively cool surfaces of the boiler itself are touched by the gases.

After a very thorough discussion of the principles underlying the design of hand-fired furnaces for high volatile coals, Mr. Monnett showed slides illustrating the application of the most general principles to various forms of mechanical stokers. He stated that the chain grate stoker was very satisfactory for the non-caking coals that are generally used in Chicago, while experience has shown that the non-caking coals, coming to the Cincinnati market from West Virginia, Pennsylvania, Kentucky, and other states, were not readily burned with high efficiency on the chain grate. He also referred to a careful study of heatings of various boilers, the measurements having been taken from hundreds of tests.

The presentation of the paper was followed by a vigorous discussion. Among those taking part in the discussion were A. G. Hall, J. J. Nelis, J. T. Faig, Members Am. Soc. M. E., and the Chief Smoke Inspector of the city of Cincinnati. There were about 100 members and guests present.

### PHILADELPHIA, OCTOBER 26

The first regular meeting for the coming season of the Philadelphia section of The American Society of Mechanical Engineers was held at the Engineers' Club on Tuesday evening, October 26. The paper was by J. A. Steinmetz, Mem. Am. Soc. M. E., and President of the Pennsylvania Aero Club. The paper reviewed in an interesting manner the development of the aeroplane in France and Germany and finally described, with lantern slide illustrations, methods of aeronautical warfare. The speaker said that as well might a blind man go forth to battle as an army without its aerial eyes. The old days of cavalry reconnaisance and of surprise turning movements of the flank are impossible because of the all-seeing eyes of the flying man high in the cloud land.

The French and German aeroplane fleets of today were built largely by public subscription. In February 1912 the potentiality of the air service was demonstrated in France, but the French government failed to allow the appropriations necessary for its development. But in every part of France the people, rich and poor, old and young, united their efforts with the press and various organizations to give France a large aerial fleet. A huge public subscription was raised which gave France 208 aeroplanes, 62 landing stations for aeroplanes and 75 trained aviators. The interest created was tremendous and the government took up the matter until in 1914 the army possessed 1200 aeroplanes and 28 dirigibles.

Germany's aeroplane fleet was built almost entirely by public subscriptions, started by the Aerial League of Germany in 1912. As in France, this popular movement led to action by the government and the Reichstag provided a plan for an expenditure of 35 million dollars for military aeronautics during the five years following. In 1914 the inducements offered by the Aerial League led to the breaking by German aviators of all the world's flying records. For instance, continuous flights of nearly 22 hours were achieved, a distance of 1336 miles was covered in one day and an altitude of 21,654 feet was reached.

The author held that just as the people in every part of France and Germany had united their efforts for the advance of aviation, so here in America the same could be accomplished, for "surely we Americans with our greater resources can do even better."

### ST. LOUIS, OCTOBER 26

Under the auspices of the St. Louis Section of the Am. Soc. M. E., the Engineers' Club, together with the associated local societies including the American Society of Civil Engineers, the American Institute of Electrical Engineers, and the American Society of Engineering Contractors, held a meeting in honor of the President and guest of the Am. Soc. M. E., Dr. John A. Brashear, on October 26 and 27. Dr. Brashear was met at the station by the Executive Committee of the Am. Soc. M. E. and William Haren, a personal friend of Dr. Brashear's, and owner of the first Brashear lens ever brought to St. Louis. After a visit through the St. Louis park system and to the Art Museum, Dr. Brashear was escorted to the City Club for lunch after which he gave a short address entitled, "Reminiscences." Dr. Brashear's talk touched on some of the most prominent facts that astronomical work has brought forth in the last century, and was interspersed with many interesting personal anecdotes. Dr. Brashear was personally a stranger to most of the St. Louis Section, and had been heralded as a maker of scientific apparatus and an astronomer, and the audience was delighted to find him also one of the most human of human beings.

The afternoon was spent in showing Dr. Brashear parts of the old section of St. Louis including the famous Shaw's Garden. At 6:30 an informal dinner was served at the Washington Hotel, at the close of which Dr. Brashear spoke a few words which left the audience with a feeling that in studying the stars and their distances into the millions of light years he was also studying divinity and humanity in the largest way. Following his remarks, Prof. Nipher gave a

short talk on the infinitely small divisions of the atom at which he was working which signified that he is studying the same vast subject as Dr. Brashear at the opposite extremity of dimension.

At eight o'clock, 1200 engineers of St. Louis with their guests assembled in the Soldan High School and listened to Dr. Brashear's illustrated story of the great telescopes of the world and the discoveries made by their use.

The next day Dr. Brashear addressed the students at Washington University at chapel and at a luncheon tendered him by the University.

### PROVIDENCE, OCTOBER 27

A meeting of the Providence Section of Mechanical Engineers was held in Brown University on October 27. The special feature of the meeting was an address, fully illustrated, by Arthur W. Dow, Mechanical Engineer of the Dow & Smith Company of New York, on the subject of Modern Highway Pavements. Invitations to the meeting were sent to city and state authorities both in Rhode Island and southern Massachusetts, and there were a great many representatives from these authorities present.

### BUFFALO, NOVEMBER 3

At a meeting of the Engineering Society of Buffalo, held on November 3, Mr. Hunt, Chief Engineer of the Packard Motor Car Company, gave a paper on the Multiplicity of Cylinders. He dwelt on the engineering relations of balance, and inertia forces, on the four, six, eight, and twelve cylinder gasoline engines. He came to the conclusion that the last is the most satisfactory. There were nearly 400 members and guests present.

### NEW YORK, NOVEMBER 9

A meeting of the New York local section, at which John J. Swan, Mem. Am. Soc. M. E., presided, was held on November 9.

Under the title, An Investigation of Gas Producer Power Plants in New York City and Vicinity, Charles Meigs Ripley, in the paper of the evening, reported the results of a census of opinions obtained from owners of private gas plants in this city regarding repairs, labor, depreciation, satisfaction with their plants or otherwise, and future installations.

The author had tabulated these data, as well as sizes, costs, loads, fuels, attendance, and ages of the plants, and presented it in the form of charts, the plants represented in which he discussed in considerable detail.

The paper was discussed by John H. Norris, Mem. Am. Soc. M. E., H. G. H. Tarr, E. Rathbun, Mem. Am. Soc. M. E., and Wm. T. Price, Mem. Am. Soc. M. E. Both paper and discussion are published in this issue of The Journal.

### MILWAUKEE, NOVEMBER 10

An interesting meeting of the Milwaukee Section was held on November 10, at which about 130 members and guests were present. At the meeting, Robert Cramer, Mem. Am. Soc. M. E., gave a paper on High Pressure Boiler Design:

High steam pressures at the present time are an established fact. A steam turbine of 20,000 kw. capacity to work under 600 lb. steam pressure is in the course of construction and is to be installed, together with boilers capable of giving this pressure, in a large power house.

The theoretical comparisons referring to the advantages of high steam pressure form the subject of a paper to be delivered by the author at the Annual Meeting of the Am. Soc. M. E. in New York City on December 8. This matter is therefore referred to very briefly here.

In the gradual development of practice in steam engineering the limit of temperature has been apparently reached with 600 deg. fahr. The limit of pressure, however, has not been reached with the current practice of slightly over 200 lb.

The justification for the introduction of high steam pressures lies in the gain in fuel economy while the practical difficulties lie in the structural parts of the steam boiler. It is necessary to retain the essential characteristics of circulation such as are found in water tube boilers at the present time, because these characteristics make it possible to handle the regulation of the fire and the feed independent of each other. The question whether circulation can be obtained in a boiler constructed entirely out of tubes is therefore of prime importance.

The characteristics of the water tube boiler, provided with steam drum and water level, are compared with that of another type of boiler made of tubes only. The point is brought out that with the latter type of boiler, steady circulation is obtained.

In realizing this point in practice, the boiler is built up of a number of so-called *Sections*, each section consisting of two headers which are connected by a number of horizontal tubes. The headers are connected to a common steam drum and a common water drum. The difficulties which arise from the operation of a number of sections in groups are illustrated, and means for meeting them are described.

The advantages of this sectional construction are also apparent in practical operation. It is possible to remove any section at any time for the purpose of cleaning and repairing. This operation can be done in day-light under conditions of perfect accessibility. After removal of the sections the interior of the furnace is easily accessible for inspection and repair.

If steam pressures of 600 lb. are employed the water in the boiler is approximately 100 deg. hotter than it is if the boiler carries only 200 lb. pressure. Other conditions being equal this will cause the flue gases to leave the heating surface of the boiler at a temperature of approximately 100 deg. higher than what is the usual practice. To offset the consequent loss in efficiency, without a large increase of heating surface, it is necessary to install a certain amount of economizer surface. The amount of economizer surface sufficient to offset this loss in efficiency is easily provided in the tubes which connect the feed drums to each individual section. These tubes of the boiler structure form a natural part of the boiler construction.

Under pressures as high as 600 lb. per sq. in., difficulties are encountered with glass water level indicators. A new construction of steel water level indicator is shown. The changes in the water, in this apparatus, influences the temperature of a mass of mercury, the expansion of which indicates the change.

In conclusion, it is pointed out that in judging any attempt to realize the advantages of high steam pressure it becomes necessary to balance the gain in fuel consumption against any increase in cost of the necessary apparatus. It is claimed that the boiler construction as shown, even under pressures

as high as 700 lb. per sq. in., does not involve a cost higher than that of present types of boilers for pressures not higher than 200 lb. per sq. in. It is therefore expected that the full theoretical benefit of high steam pressures can be realized in practice.

## LOS ANGELES, NOVEMBER 13.

The Los Angeles Section of The American Society of Mechanical Engineers held a very successful meeting on November 13. During the afternoon and evening the members and their guests visited the laboratory of the Mt. Wilson Solar Observatory and inspected the new 100 in. mirror for the reflecting telescope now being erected on Mt. Wilson, as well as the grating ruling machine, and the mechanical and physical equipment of the laboratory. Dr. Hale spoke briefly in regard to the purpose and aims of the Observatory illustrating his talk with actual photographs and slides.

Dinner was served at the Hotel Maryland, forty-three members and invited guests being present. After the dinner, F. G. Pease, Mem. Am. Soc. M. E. and of the Observatory staff gave a talk that was profusely illustrated with lantern slides illustrating the mechanical equipment of the laboratory and its work. The laboratory and the observatory equipment are unique in that they are designed and built in the observatory shops, the equipment being designed from the standpoint of the mechanical engineer rather than the standpoint of the instrument maker.

## BUFFALO, NOVEMBER 17

The Engineering Society of Buffalo held a successful meeting on November 17 at the J. P. Devine Company's plant in Buffalo, at which John Calder, President of the Metals Coating Company of America, addressed the Society on the Schoop Process of Spraying Metals. The lecture was accompanied by a very interesting demonstration of a process new to America, the coating of wood, paper, iron, steel and other substances with metals.

The importance of the process which was brought to this country by Mr. Calder from Switzerland, is, as regards steel-and-iron construction, the arrest of corrosion and rust. Mr. Calder explained that that tuberculosis which iron and steel suffers from, has been arrested to some extent temporarily by paints, enamels and their substitutes.

It is important in the preparation of food products that the vessels used do not corrode. It is important also in construction that the irons and steels do not rust; that the other metals used resist decay. Each material can be coated, to any practicable thickness desired, with electro-positive, non-corroding metals.

Bronze wires, brass wires, aluminum, lead and copper wires were melted a tiny drop at a time during the demonstration. These drops of melted metal were thrust through a spraying brush with oxygen at the rate of 3,500 ft. a second. The metal thus treated is, theoretically, blown into its component molecules. These are thrust into the fiber, grain or texture of the object and, as the spraying continues, a hard surface or coat of the metal is deposited. The coated surface may be polished if desired.

The coating process had developed a new business in novelties. Various articles, apparently metal, are now being marketed at low prices which, the lecturer explained, are really wood coated with bronze or other metals. For the engineers the chief interest was, of course, the demonstration of the claimed effective prevention of decay, which threatens all structural metals. The paper called forth considerable discussion regarding the possibilities of this process. Nearly 250 members were present.

## NEW HAVEN, NOVEMBER 17

The splendidly managed fall meeting of the New Haven section was held in the Mason Laboratory of Sheffield Scientific School on Wednesday, November 17. Afternoon and evening sessions were held and about one hundred and fifty were in attendance.

Dr. L. P. Breckenridge, Mem. Am. Soc. M. E., presided in the afternoon while Charles L. Warner, Mem. Am. Soc. M. E. presented a paper on the ingenious wire-forming machines made by the Baird Machine Company, of which he is president. Albert A. Dowd, consulting engineer of New York City and on the staff of Machinery, gave most valuable information and shop hints on work-holding devices for lathes, boring mills and planers.

It is papers like the latter which return to the member of the Society many times the amount of a member's dues. The other papers were highly interesting and instructive and presented by authorities in their respective specialties, but Mr. Dowd was able to give suggestions which would save shops hundreds of dollars.

At the completion of the afternoon session, a dinner was served in the inspiring Yale Dining Club Hall.

Prof. J. W. Roe, Mem. Am. Soc. M. E., presided in the evening, when Calvin W. Rice, Secretary Am. Soc. M. E., spoke for a few moments. He stated that it would be taken for granted that the Society was especially successful so he wanted to emphasize the success of all the societies and the profession generally. Coöperation of the societies in the International and Panama Congresses, in legislative matters, with the United States in the Naval Advisory Board and in the as yet unannounced work with the War Department, indicated the more leading part the engineers are taking in society generally. Coöperation between the engineering societies in local affairs was urged and a joint meeting for the 1916 spring meeting in New Haven suggested.

Ralph E. Flanders, Mem. Am. Soc. M. E., followed with a splendid presentation of the subject of gear cutting machinery. Geo. O. Gridley, Mem. Am. Soc. M. E., who has contributed perhaps more than anyone to the advancement of the art of automatic screw machines, closed the session.

## MINNESOTA, NOVEMBER 18

The November meeting of the Minnesota Section of the Am. Soc. M. E. was held at the University of Minnesota on November 18. At the afternoon session three papers were read, one by Ray Mayhew, Mem. Am. Soc. M. E., and Mechanical Engineer of the Minneapolis Steel & Machinery Company, on Stationary Gas Engines, one by S. C. Shipley, Mem. Am. Soc. M. E., and Assistant Professor of Machine Construction of the University of Minnesota, on Gas Engine Ignition, and one by W. G. Clark, Engineer for the Wilcox-Bennett Carburetor Company of Minneapolis, on Carburetion in Gas Tractor Work. Following this a dinner was served in the Minnesota Union.

At the evening session two papers were presented, one by E. Russell Greer, Mechanical Engineer for the Lion Tractor Company, on Gas Tractor Engines, and one by S. L. Hoyt, Assistant Professor of Metallography at the University of

Minnesota, on the Use of Special Steel in Gas Tractors and Automobile Construction. There was a total attendance of 145 members, visitors and students.

### PROVIDENCE-BOSTON, NOVEMBER 18

A very successful joint meeting of the Providence Association of Mechanical Engineers and the Boston Section of the Am. Soc. M. E. was held in Providence on November 18. In the afternoon a choice of excursions was given to the Gorham Manufacturing Company, the largest firm of silversmiths in America; the General Fire Extinguisher Company, the largest fire prevention company in the world, and the Brown & Sharpe Manufacturing Company, so well known for the high grade tools and machines manufactured. The last part of the afternoon the members and guests were cordially received and entertained by the Brown University authorities in the engineering laboratories. Following this, a banquet was served at 6:15 at the Hotel Narragansett. The meeting was presided over by A. H. Annan of the Providence Association, and he introduced William Howard Paine as toastmaster. The visiting members to the city were cordially welcomed by His Honor Mayor Joseph H. Gainer. Following this, Dr. W. H. P. Faunce, President of Brown University, spoke of the engineers, not as malefactors but as factors of great wealth, and said that to judge by the attendance of over 500, engineering appears to be as popular as politics. He mentioned the need of applied science and the necessity of harnessing thinking with practical work to bring results and value to the world at large.

Prof. Charles E. Munroe, Dean of George Washington University, gave a very interesting and instructive discussion of the subject of Explosives and the Engineer, pointing out the various characteristics in different kinds of explosives, giving their history and important results achieved. To illustrate the enormous amount of explosives used he mentioned that nearly 9,000,000 lb. per year had been used at Panama, and that on October 10, 1885, Hell Gate was blown up by a charge of 285,000 lb. of dynamite and rackarock, this being the largest charge ever set off at once, and blowing up an area extending over nine acres.

Morris L. Cooke, Director of Public Works at Philadelphia, spoke of his experiences as an engineer in public office. He stated that public business should be modeled on private business, that city governments as a rule have little control over, or knowledge of public service corporations, and that the greatest accomplishment of a municipal engineer or contractor of public works can be in connection with public utilities. He stated that people did not object to authorizing the expenditure of money, provided they got objective evidence that they were to receive one dollar's value for one dollar expended.

Next followed an exposition of the development of an international telephone system by M. C. Rorty, Engineer of the American Telephone and Telegraph Company, illustrated by moving pictures, and later by actual conversation with San Francisco, each one present being provided with an individual receiver. This feature was carried out through the courtesy of the management of the American Telephone and Telegraph Company.

The joint meeting was a very successful one and there were nearly 600 members present at the banquet. The papers which were presented appear in the technical section of this issue of The Journal.

### PHILADELPHIA, NOVEMBER 23.

A meeting of the Philadelphia local section was held on November 23, 1915, at which W. P. Barba of the Midvale Steel Company presented a paper on Industrial Safety and Principles of Management. This paper is printed in full in another part of this issue.

## NECROLOGY

### ROBERT A. MC KEE

Robert A. McKee was born on September 12, 1873, in Towanda, Pa. He graduated from Lehigh University with the degree of M. E., in 1895. For a short time after graduation he was employed by the Brooks Locomotive Works of Dunkirk, N. Y., as draughtsman and designer. He then went to Cornell University to take a course in Marine Engineering, receiving in 1897 the degree of M. M. E. Returning to the Brooks Locomotive Works, he worked in the capacity of designer. In 1899 he became connected with the Baldwin Locomotive Works, remaining there until 1900, when he took a position with the Holly Manufacturing Company of Lockport, N. Y. Here he started as a tracer and was rapidly advanced to the position of leading designer. After fifteen months he left this position to enter the employ of the Westinghouse Machine Company at East Pittsburgh, Pa. In 1904 he was engaged by the Allis-Chalmers Company to take charge of the development and construction of steam turbines. It was due to his efforts more than those of any other individual that the steam turbine department developed along lines which have proved to be based on correct fundamentals. His advice on steam problems was sought by leading engineers and his reputation as a steam turbine engineer extended to foreign countries. Mr. McKee was a member of the American Institute of Electrical Engineers. He died in New York on September 5, 1915.

### RAYMOND EARL CRANSTON

Raymond Earl Cranston was born in Providence, R. I., on November 25, 1883. He was educated in the Providence schools, spent one year in Brown University, and graduated with honor in 1906 from Massachusetts Institute of Technology with the degree of B. S. He then entered the employ of the Manufacturers' Mutual Fire Insurance Company of Boston. Later he was sent to the Providence office and became associated with John R. Freeman in his private engineering work. In 1912 he went to California with Mr. Freeman as assistant on the Hetch-Hetchy water supply for San Francisco. Soon after he became assistant engineer for the insurance company.

Mr. Cranston was a member of the Providence Society of Mechanical Engineers. He died at his home in Providence on June 25, 1915.

### JOHN LOYD

John Loyd was born in Newton, Mass., on May 1, 1837. He received his education in the public schools, and learned the machinist and engineering trades. At the outbreak of the Civil War he entered the United States Navy. He was commissioned as acting third assistant engineer and was later promoted to first assistant engineer. On May 7, 1867, he was ordered to the Portsmouth Navy Yard as assistant engineer, and was granted an honorable discharge Decem-

ber 27 of the same year. Shortly afterward he started into business in New York City in the manufacture of machinery, knives and dies under the firm of McLoughlin, Grover and Loyd. On the death of his partners he continued the business under the name of the John Loyd Company.

Mr. Loyd was a member of the Military Order of the Loyal Legion, the Navy League, the Society of Naval Architects and Marine Engineers, the American Society of Naval Engineers and the Metropolitan Museum of Art. He died at his home in Brooklyn on October 5, 1915.

### HORACE WYMAN

Horace Wyman, whose death occurred on May 8, at his country home in Princeton, was born in Woburn, Mass., on November 27, 1827. He was educated in the academies at Woburn and Francestown, N. H., and began his business career in 1846, when he became a machinist in the works of the Amoskeag Manufacturing Company at Manchester, N. H. He was later employed by the Lowell Machine Company and by the Hinckley Locomotive Works at Boston, and served as draughtsman with the Holyoke Water Power Company.

About 1860 Mr. Wyman became associated with George Crompton of Worcester. He was made superintendent and manager of the Crompton Loom Works, holding that position until the consolidation of the business under its present name of Crompton & Knowles Loom Works. Mr. Wyman was then made vice-president and consulting mechanical engineer of the company, retaining that position until his death.

All through his many years of service with the Crompton and the Crompton & Knowles Loom Works he applied himself to invention of looms and textile machinery until he had practically perfected looms as they are now used. His inventions made it possible for woolen, gingham and silk fabrics to be woven in more than one color and in larger pieces than before. Through the processes developed by him, rugs and carpets can now be manufactured in size large enough to cover the floor of a room. Textile mills all over the country are using every day machines invented by Mr. Wyman. He is regarded as having done more for the loom industry than any other man in Worcester and possibly in the country. His inventions were the largest single factor in the success of the Crompton & Knowles Loom Works.

He was a member of the Worcester County Mechanics' Association and the Worcester Society of Antiquity.

### WILLIAM WATSON

William Watson was born in Nantucket, Mass., on January 19, 1834, and died at his home in Boston on September 30, 1915. He graduated from Harvard in 1857, and took the Boyden prize for mathematics in which he excelled in his work in engineering. The same year he became an instructor at Harvard in differential and integral calculus. Later he took a course of special study at the École Nationale des Ponts et Chaussées in Paris. On returning to this country he became university lecturer at Harvard. While in Europe, Prof. Watson collected from 1860 to 1863 information on technical education which was made the basis of a plan of organization in 1864 of the Massachusetts Institute of Technology, where from 1865 until 1873 he was professor of mechanical engineering and descriptive geometry.

Professor Watson was United States Commissioner in 1873 to the Vienna Exposition and he served as a member of the International Jury of the Paris Exposition in 1878. He had been honorary president of the Paris Congress of Architects and vice-president of the engineering section of the French Association for the Advancement of Science, serving several terms, and vice-president of the International Congress of Construction in 1889.

He was a member of the French National Academy at Cherbourg, Société des Ingénieurs Civils de France and the American Society of Civil Engineers. He was a fellow of the American Academy of Arts and Sciences, member of the American Association for the Advancement of Science, the Colonial Society of Massachusetts and the Mathematical Club. He was the author of many notable works on technical education and science, engineering, architecture and other subjects.

### WALTER SEAVER BALL

Walter Seaver Ball was born March 17, 1867, at Upton, Mass. He was educated in the Upton schools and graduated from Worcester Polytechnic Institute with the degree of S. B. in 1889. He was associated for a short time with the Dean Steam Pump Company at Holyoke, and in 1894 he became connected with the McKay Metallic Fastening Association as assistant to the superintendent. He then became assistant superintendent with the United Shoe Machinery Company and later moved from Winchester to Beverly with this company. For twenty-three years Mr. Ball held a position of great responsibility with the allied companies making this great industry. He died on September 11, at the Beverly Hospital.

### TEILE HENRY MÜLLER

Teile Henry Müller was born January 18, 1841, at Grossensiel-Oldenburg, Germany, and was educated at the Polytechnic School of Hannover, completing the course in mechanical engineering in 1862. He then entered the service of the North German Lloyd Steamship Line as ship engineer. In 1865 he came to New York and was engaged first as machinist and later as draughtsman by the Root Steam Engine Company. He left this firm in 1866 to accept a position as superintendent engineer with the Convex Weaving Company, designing and building their mill and machinery. He then took the position of superintendent with the Eagle Pencil Company to redesign their machinery and revise the processes of manufacturing pens, pencils and other articles. In 1877 he entered the employment of S. S. Hepworth & Company, sugar engineers, as superintendent. He designed the California Sugar Refinery in San Francisco for Claus Spreckels and the Belchers Refinery in St. Louis, and built a large part of the machinery for these factories. Later he designed and built the Spreckels Refinery in Philadelphia, the National Sugar Refinery in Yonkers, and designed and partly built the Camden Sugar Refinery. In 1900 he was engaged by the Federal Sugar Refining Company as constructing engineer and built their works in Yonkers in 1914. Mr. Müller continued in this position until the time of his death, which occurred on September 21, 1915.

### WALTER K. MITCHELL

Walter K. Mitchell was born October 13, 1866, in Glasgow, Scotland, and came to this country very early in life. He was educated in the schools of Pittsburgh and served an apprenticeship as machinist with the Jones & Laughlin Steel Company. From 1889 to 1899 he was employed as sales engineer by Best Fox & Company of Pittsburgh, piping

engineers and contractors, going to Philadelphia as their eastern representative in 1893. In 1899 he formed the partnership of W. K. Mitchell & Company, specializing in high pressure piping and its accessories. When this partnership was changed to a corporation in March 1909, Mr. Mitchell was elected president and treasurer. He continued actively in these offices up to the day of his death, which occurred on November 6, 1915.

### AUGUSTUS JAY DU BOIS

Augustus Jay DuBois was born April 25, 1849. He was graduated from the Sheffield Scientific School in 1869, and was awarded the degree of civil engineer in 1870 and the degree of doctor of philosophy in 1873. Later he studied mechanics for two years at the Mining Academy in Freiburg, Saxony, and from 1875 to 1877 he was Professor of Civil Engineering and Mechanical Engineering at Lehigh University. In 1877 Professor DuBois was appointed Professor of Mechanical Engineering in the Sheffield Scientific School and in 1884 was transferred to the Professorship of Civil Engineering which position he occupied until his death.

Professor DuBois was the author of some of the best-known treatises on mechanics and stresses in the English language. His book on Graphic Statics, published in 1876, was largely instrumental in introducing to American engineers the graphic method of determining stresses in framed structures now so widely used. This was followed by his translations of Röntgen's Thermo-dynamics, Weyrauch's The Calculation of the Strength and Dimensions of Iron and Steel Construction, and Hydraulics and Hydraulic Motors and Heat, Steam and the Steam Engine from Röntgen's Mechanics. In 1883, his elaborate and original book on Strains in Framed Structures took its place as one of the most important contributions to engineering literature, being perhaps the first comprehensive treatment of the subject. A series of books on mechanics culminated in his Mechanics of Engineering published in 1901.

Professor DuBois was a member of the American Society of Civil Engineers, the American Institute of Mining Engineers, the Connecticut Society of Civil Engineers and the Society for the Promotion of Engineering Education. He died on October 19, 1915.

### DWIGHT E. LYMAN

Dwight E. Lyman was born in Marshall, Oneida County, N. Y., on October 12, 1845. He was educated in the Deansville schools, and served an apprenticeship at the Willowvale Machine Works of Utica. Later he was employed for four years as superintendent and draughtsman by Keeney Bros. of Manchester, Conn. At the age of 20, he went to Hartford, and soon entered the employ of Asa S. Cook, serving as superintendent and mechanical engineer from 1875 to 1882. After this for one year he held a similar position with the Syracuse Screw Company, returning in 1833 to the Asa S. Cook Company as superintendent, the position he held at the time of his death. Mr. Lyman died at his home in Hartford on July 8, 1915.

### JOHN E. WARREN

John E. Warren was born in Grafton, Mass., on October 7, 1840; but when he was still an infant his parents travelled West as pioneers and settled on a farm in Wisconsin, where the boy grew up. The short term country schools of the day supplied all there were of his opportunities for schooling, except that he supplemented them afterward for a time by teaching, and then by entering Ripen Academy shortly before the outbreak of the Civil War. He promptly enlisted in the Union Artillery, and served with it through to the end.

Not long afterward he entered the employ of S. D. Warren & Co., makers of book paper. It was to this company at its plant at Cumberland Mills, Maine, that Mr. Warren devoted his business and professional service to the close of his life. He began as a mechanic, worked upward through various capacities, until in 1883 he was appointed Agent of the Mills, thus becoming the head and leader of its organization, the position which he retained for thirty-two years, up to his death. His interest turned naturally to engineering. The expansion of the mills, their growth which multiplied their capacity and value over four times during his administration of them, brought out the need for engineering services of high order.

Mr. Warren had been a member of the Society since 1886. He died on August 13, 1915.

## PERSONALS

Gustave Eiffel, Hon. Mem. Am. Soc. M. E., has been appointed by the French Minister of War on the Consulting Committee of Experts on Military Aeronautics.

Charles E. Burgoon has resigned from the position of inspector of mechanical and electrical engineering with the Panama Canal, Washington, D. C., and has been appointed chief mechanical and electrical engineer with the Carbolite Chemical Company (Tennessee Copper Company), Copperhill, Tenn.

Thomas C. Shedd has resigned his position as instructor in mechanical engineering at Brown University, Providence, R. I., and has accepted a position with the Phoenix Bridge Company, Phoenixville, Pa., as draftsman.

Forrest W. Manker has become associated with the Moulton Engineering Corporation, Portland, Me. He was until recently connected with the B. F. Sturtevant Company as manager of their Hartford, Conn., office.

Cleon E. Phelps, formerly affiliated with the physical laboratory of the American Steel and Wire Company, Worcester, Mass., as mechanical engineer, has accepted a similar position with the American Optical Company, Southbridge, Mass.

Fred J. Bechert has resigned his position as instructor of mechanical engineering in the Texas Agricultural and Mechanical College, College Station, Texas, and has accepted the position of assistant examiner in the United States Patent Office, Washington, D. C.

The Lavigne Gear Company, Racine, Wis., one of the most extensive manufacturers of steering gears for pleasure and commercial vehicles in the United States, has been reorganized, its corporate name being changed to Lavine Gear Company. Mr. Herman A. Uihlein is president and treasurer of the company.

B. A. Behrend is the author of a brief article on Balanced Engineering which appears in the November issue of the Electric Journal.

John C. Parker has resigned as head of the engineering department of the Rochester Railway and Light Company, Rochester, N. Y., to accept the chair of electrical engineering at the University of Michigan, Ann Arbor, Mich.

Some Facts about Insulation by Henry A. Cozzens, Jr., is published in the November number of Electrical Age.

P. D. Wagoner was elected one of the directors of the Electric Vehicle Association of America at the October 18 and 19 convention in Cleveland.

Dr. Charles P. Steinmetz was elected, on November 2, president of the Common Council of the city of Schenectady, N. Y., on the ticket of the local socialistic party.

One of the many papers presented at the 23d annual meeting of the Naval Architects and Marine Engineers, November 18 and 19, in New York, was Some Comparisons Relating to Electric Propulsion of a Battleship by W. L. R. Emmet.

George K. Miltenberger, who has been stationed at Hickman, Ky., for several months in the capacity of local manager of the Public Service Company, which operates the city light and water plants, has been transferred to St. Louis.

A. J. Purinton, who was formerly manager of the East St. Louis, Ill., Light and Power Company, has accepted a position as general superintendent of the Atlantic City and Shore Railroad Company at Atlantic City, N. J.

Harold Carpenter, resident engineer of the Astoria Tunnel, Astoria Light, Heat and Power Company, New York, has contributed an article on Flooding and Recovery of the Astoria Tunnel to the November 1 issue of The Gas Age.

The Chamber of Commerce of Worcester, Mass., announces that an International Road Congress will be held in that city December 14 to 17, inclusive. The Massachusetts Highway Association and the Federal Government will coöperate with the local authorities in conducting the meeting. Among the engineers on the program for the Congress are Clifford Richardson, W. W. Crosby and Ira N. Hollis.

Nathan C. Johnson is a member of the advisory committee appointed by the United States Bureau of Standards to report upon the advantages of the use of hydrated lime in concrete.

Walter N. Polakov has resigned as superintendent of power of the New York, New Haven and Hartford Railroad, to engage in consulting practice. In the 18 months he had charge of the operation of the power plants of the New Haven, he effected a saving of 25 per cent in the cost of electric power.

Paul M. Lincoln has resigned from his position in the engineering department of the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa., to devote his time to the manufacture of a meter which he has recently developed.

A. C. Dinkey, formerly president of the Carnegie Steel Company, Pittsburgh, Pa., now president of the Midvale Steel Company, Philadelphia, was tendered a farewell banquet by 60 operating officials of the Carnegie Company, October 30, at the Duquesne Club, Pittsburgh. Judge J. H. Reed presided.

Among those presenting addresses at the 19th annual convention of the National Founders' Association which was held at the Hotel Astor, New York, November 17 and 18, were M. W. Alexander and Albert G. Duncan.

Henry D. Sharpe, treasurer of the Brown and Sharpe Manufacturing Company, Providence, R. I., has given $1000 toward a fund for a new home for the Providence Boys' Club, and also $100 to the military aeroplane fund of Rhode Island.

Dr. John A. Brashear, President Am. Soc. M. E., has been appointed a delegate to the Pan-American Scientific Congress, which will meet in Washington, D. C., December 27 to January 7.

F. C. Trowbridge has been elected president of the Manufacturers' Association of Hamilton, O., which has recently been organized. The object of the association is to bring about closer coöperation between employers and their employees and later on it is proposed to take up the matter of industrial education.

Frank A. Burr, formerly associated with the Spray Engineering Company, Boston, Mass., has been appointed instructor in power plant design at Pennsylvania State College.

Among those who took part in the addresses and discussions given at the conference on valuation held in Philadelphia, November 10 to 12, were: Morris Knowles, H. P. Gillette, Morris L. Cooke, Manager Am. Soc. M. E., John R. Freeman, Past President, Am. Soc. M. E., and Leonard Metcalf.

The November issue of Machinery which is largely devoted to safety and welfare work in manufacturing plants and selling organizations, contains a contribution by Forrest E. Cardullo on A Study of Safety and Welfare Work in Manufacturing and Selling Organizations. This article covers comprehensively safety and sanitation, housing of employes, coöperative organizations, profit-sharing systems, pensions, workmen's compensation, etc. Another article on this subject, entitled Safety Organizations of a Machine Shop, has been contributed by Luther D. Burlingame.

Frank O. Hoagland, works manager of the Union Metallic Cartridge Company, Bridgeport, Conn., has resigned the position to become assistant to B. M. W. Hanson, vice-president and works manager of the Pratt and Whitney Company, Hartford, Conn.

W. H. Winterrowd is the author of an article on First 4-8-2 Locomotives in Canada which appears in the November issue of the Mechanical Edition of the Railway Age Gazette.

A. L. Graburn, mechanical engineer of the Canadian Northern at Toronto, Ont., Canada, has been appointed assistant superintendent of rolling stock of the Eastern lines, with office at Toronto.

A. E. Ostrander has been appointed mechanical engineer of the American Car and Foundry Company, New York, succeeding John McE. Ames who recently resigned. Mr. Ostrander entered the service of the American Car and Foundry Company in 1903 and has been with the company continuously since that time.

Alan A. Wood, previously at the Providence, R. I., office of the Builders Iron Foundry as sales engineer in the venturi meter department, has become associated with their Pacific Coast agents, Norman B. Livermore of San Francisco and Los Angeles, in an engineering and sales capacity.

George H. Thorpe, until recently connected with the Millville Manufacturing Company, Millville, N. J., has accepted a position with John A. Stevens of Lowell, Mass., in the capacity of mechanical engineer.

H. O. Hem, formerly vice-president and superintendent of the H. N. Strait Manufacturing Company, Kansas City, Mo., has become a member of the engineering staff of the Toledo Scale Company, Toledo, O., in the capacity of consulting engineer.

Frank E. Watkins has become connected with the East Jersey Pipe Corporation, Paterson, N. J., as works manager. He was formerly associated with the Canadian Fairbanks-Morse Co., Ltd. of Toronto, Ontario, Canada.

Williams Alston Stevenson, former member of the Society and brother of A. A. Stevenson died on October 22. He was a graduate of Lehigh University of the class of 1890. Shortly after graduation he was made superintendent of the Stearne Manufacturing Company at Erie, Pa., and later superintendent of the Akron Plant of the Wellman-Seaver-Morgan Company. For a number of years previous to his death he was general manager of the Keystone Drop Forge Works at Chester, Pa.

J. Harland Billings has become associated with Johns Hopkins University as instructor in mechanical engineering.

## STUDENT BRANCHES

### ARMOUR INSTITUTE OF TECHNOLOGY

The opening meeting of the Armour Institute of Technology Student Branch was held on October 21. The meeting was in the form of a smoker to which the Junior students in mechanical engineering were invited. J. M. Byanskas, president of the Branch, opened the meeting and outlined the policy for the coming year. Professor Gebhardt further discussed the plan which is to have more open discussion of important topics in which everyone takes part rather than have outside speakers.

### CARNEGIE INSTITUTE OF TECHNOLOGY

The Student Branch of the Carnegie Institute of Technology held its first meeting of the school year on October 13. A. V. McNamara, president of the Machinists Union, spoke on the Relation that should exist between the Engineer and the Workmen in the Shop. He explained fully his position as leader of the movement that is making such a strenuous campaign to procure better wages, working hours and working conditions for the workmen. He declared himself to be strongly in favor of woman suffrage and expressed his opinion that that movement would be a great effect in producing a more desirable situation for workmen.

He then made an analysis of the relation between the workmen and the engineer. He showed how deplorable it is that many concerns maintain such a wide gap between the engineering department and the shops. In this connection, he pointed out with examples how the workman discovers and rectifies points that the engineer has not recognized, and which the workman cannot bring to the engineer's attention. Mr. McNamara called attention to the fact that all labor laws and improvements were brought about through the efforts of organized labor and that the engineers benefited just as much by them as those who had brought them about.

Following the address, there was an extended discussion upon open shops, the violation of labor laws by manufacturers, the bad effect of liquor and future prospects. Mr. McNamara expects that the next big movement in labor organization will be the consolidation of all of the unions.

### CASE SCHOOL OF APPLIED SCIENCE

The first regular meeting of the Case School of Applied Science Student Branch was held on November 3. An illustrated address on The Electrification of Steam Roads Within the City Limits of Cleveland was given by E. P. Roberts, City Smoke Inspector. Mr. Roberts showed the importance of the problem of the electrification of the steam roads entering the city, since the citizens as well as the railroads are benefited by the increased prosperity of the city. He urged that no construction work should be allowed that would interfere with electrification whenever it should come. The advantages to the city that would come as a result of this step would be: first, the elimination of smoke and cinders; second, the increased traffic facilities; third, the possible suburban traffic and the improvement of the interurban. The areas affected by the smoke and cinders of the steam roads now in use represent 65 per cent of the entire city area, the affected zones being taken a thousand feet on either side of the track. Of this the cinder area is one fifth or 13 per cent of the city area. The greater part of the smoke is from switching engines which are used every day at the rate of 122 per hour, against 24 freight and 12 passenger locomotives per hour. The only method of smoke abatement possible with present systems is a change in equipment, which would be almost as expensive as electrification. In comparing the smoke emitted by locomotives and that from other sources, it was stated that black smoke is emitted much oftener and in larger quantities by the locomotives because of their construction, and the damage and annoyance due to smoke from locomotives is greater, since there is no high stack to carry up the smoke and fumes and so spread them out over large areas. The speaker discussed also the various systems of electrification available, including both direct and alternating current types using trolley wheel, pantograph or third-rail contractors. He concluded by recommending careful and immediate consideration of this problem.

### KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College Student Branch held on November 4, A. Douglas was elected treasurer. Prof. G. B. McNair gave a talk on a Summer at the Westinghouse School for Teachers. J. H. Welsh read a paper on The Flour Mill at Kansas State Agricultural College. This is a model mill with all the modern equipment. Mr. Welsh told of the different processes the whole wheat must pass through before it is converted into flour, and described the arrangement of the machinery. Gabe Sellers reviewed an article on the Panama-Pacific International Exposition, which appeared in the October issue of The Journal, and J. J. Abernethy gave a talk on Clayton's Analysis, taken from a bulletin publication of the University of Illinois.

### LEHIGH UNIVERSITY

The first meeting of the Lehigh University Student Branch was held on October 28 at which M. W. Kresge, '16, gave a talk on Military Engineering and L. Mardaga, '16, gave a talk on Surface Condensers. Mr. Kresge's talk dealt with his experiences with Engineer Companies at Student's Military Instruction Camps. He spoke briefly on field engineering, permanent fortifications, building of bridges and reading and drawing military maps. Mr. Mardaga spoke of condensers as connected with their use in the low pressure steam turbine. He also spoke of various apparatus used to produce the necessary vacuum and made a few remarks affecting the design of a surface condenser.

At a meeting on November 18 the best talk was by Prof. T. E. Butterfield, who spoke on "Diesel Engines." Professor Butterfield gave a brief history of the early development of these engines and also a general talk on the modern Diesel Engines illustrated by lantern slides.

The second speaker was J. M. Wells, '16, who described the trip of the Senior Mechanicals to the L. C. & N. Co.'s power plant at Haute on November 3.

J. M. Bausman, '16, spoke on "Schrapnel." He described manufacture of cases, schrapnel, and fuse, giving methods of pressing out cases and steel casings and finishing them. He also spoke on the contents of the steel casing and the workings and object of the fuse.

### LELAND STANFORD, JR. UNIVERSITY

A business meeting of the Leland Stanford, Jr. University Student Branch was held on October 13, 1915. A large part of the meeting was devoted to a discussion of an amendment to the constitution whereby the dues of regular members shall be fixed at $4.00 per year with an additional initiation fee of $1.00 for new members. This will include a subscription to The Journal. This amendment will be put to a vote at the next meeting of the Branch.

At this meeting, J. L. Reynolds gave a very interesting talk on a plant for the extraction of gasoline from the "wet" natural gas which comes from wells producing oil with a parafine base.

On October 27, thirty-six new members and Department members of the faculty were entertained at a smoker given at El Campo. Prof. W. F. Durand spoke on the advantages derived from the formation and work of Engineering Societies and Associations and the value of being connected or affiliated in some way with one of them.

Prof. G. H. Marx spoke on the initiative of the western student, and made a brief forecast of engineering activities for the next few years.

### OHIO STATE UNIVERSITY

The Student Branch of the Ohio State University of American Society of Mechanical Engineers held a regular meeting on November 12 and were entertained at the home of Prof. and Mrs. Wm. F. Magruder.

Officers for the present semester were elected, and the programme for the year was discussed. It was decided to fea-

ture the meetings with talks from prominent engineers in the City of Columbus, and by papers written by members of the society.

The officers elected were as follows: Harold H. Brooks, president; Hugh V. Walborn, vice-president; Ray Ellis, secretary; Maurice A. Nettleton, treasurer; Alex. F. Landefeld, sergeant-at-arms.

### PENNSYLVANNIA STATE COLLEGE

The regular monthly meeting of the Pennsylvania State College Student Branch was held on October 28. An illustrated lecture on the Panama Canal was given by H. P. Vail, who was employed in engineering work there during the past summer. Mr. Vail discussed the methods used in the construction of the canal and told of its operation as a waterway and of the improvements in sanitation which this Government has brought about. He also described the operation of the locks, explaining how the lock engineer, at a switchboard with a miniature layout of the system, has full control of a whole system of locks.

### PURDUE UNIVERSITY

The first meeting of the Purdue University Student Branch, held on September 28, was a general get-together meeting, at which refreshments were served and talks were given by some of the professors.

At a meeting on October 12, William Borgard spoke on Electric Starting, Lighting and Ignition Systems and Their Failings.

At the third meeting of this Branch on October 26, an interesting talk was given by J. H. Emrik of the Senior Class on Automatic Adding Machines of the National Cash Register Company and also on the Company's Products, Organization and Welfare Work.

The idea for the cash register came to the originator on an ocean liner where he saw a revolution counter in use. The first register built counted only to a dollar, but great and rapid advancements have been made until now, it is a necessity in stores, both as a protection and an aid to the store manager against employees. Those of the latest design even furnish the customer with a receipt.

It is very essential that the cash register be designed and made very accurately and carefully. Often careless and inexperienced clerks operate the machines and certain parts have to be made heavier to withstand abuse. Above all, the machine must add correctly.

For the purpose of giving information, separate counters, separate transaction counters, customer counters, total counters and a variety of others are provided.

When Mr. Emrick had finished his talk on the cash registers, he was asked to tell about the welfare work which the Cash Register Company is doing for its employees. Apprentice courses are provided in every profession and trade found in the plant, and both day and evening classes of every kind are held. The lecture course is of a very high type and very often motion pictures illustrating the making of several kinds of manufactured products from rough material to the finished products are used in connection with the lecture. A library is also provided at a nominal cost to the readers. Athletic sports of all kinds are provided, including a country club for golf, and there is a well organized medical department, which is at the disposal of the employees for a small fee.

### STATE UNIVERSITY OF KENTUCKY

At a meeting on September 24, the State University of Kentucky Student Branch was organized and the following officers were elected: Prof. F. P. Anderson, honorary chairman; J. D. Garrett, chairman; H. Worsham, vice-chairman; G. L. Cherry, secretary and treasurer. The chairman appointed T. C. Taylor chairman of the porgram committee, to be assisted by H. Worsham and H. E. Melton. The governing committee, composed of the officers and Professor Anderson as ex-officio member, was appointed.

At a meeting of the branch on October 29, N. C. Johnson's paper on the Hydration of Portland Cement, which appeared in the September issue of The Journal, was discussed and illustrated by means of a projectoscope. The other articles discussed were The Connors Creek Plant of the Detroit Edison Company and Graphical Tables for Calculating Reciprocating Compressors.

### UNIVERSITY OF CALIFORNIA

At a meeting of the University of California Student Branch on October 26, a paper on Electric Arc and Percussive Welding was read by E. Eichler.

The following officers were elected at a meeting of the branch held August 31: C. Sebastian, chairman; M. Jones, vice-chairman; E. Eichler, secretary; H. Crow, treasurer.

### UNIVERSITY OF CINCINNATI

Afternoon meetings of the University of Cincinnati Student Branch of the American Society of Mechanical Engineers were held October 7 and 28 for the purpose of explaining to the underclassmen, in Sections I and II, what the American Society of Mechanical Engineers is, its mission and work in the University. Talks were given by Prof. J. T. Faig, Prof. A. L. Jenkins, and C. Joerger. At the close of the meetings opportunity was given to the visitors to become members and forty men signed up.

On the afternoon of October 21 an open meeting was held, at which G. A. Monnett, formerly Chief Smoke Inspector of Chicago and Associate Editor of Power, was the speaker. His main topic was boilers, boiler settings and draft. A great many slides of different makes of boilers in their settings were shown, accompanied by tables showing the draft at different points in the setting. An interesting history of the development of the Chicago Standard Setting was given.

The first evening session and smoker was held October 29 at which Mr. Mittendorf, Assistant Chief Engineer of the Cincinnati Traction Co., spoke on tests of different coals, carried on by him, in order to determine the most economical coal for use in their power plants. The tests were run in their own plants, under ordinary working conditions, with the same draft, and with average firemen. The coal in Cincinnati comes from five or six different states, and the coal from each field is different from that of every other.

In order to show high over-all economy for a company, the coal must not be too expensive, must be adaptable to the present furnaces of the company, must show a high number of lb. of water evaporated per lb. of coal, must not be too high in ash, be free from clinker, and comparatively near for low freight rates.

A chart was shown, giving the results of these tests on the different kinds of coal. The advantages and disadvantages of the different coals were clearly shown.

### UNIVERSITY OF COLORADO

At a meeting of the University of Colorado Student Branch on October 28, F. G. Gardner of the Department of Safety of the Interstate Commerce Commission read a paper on Mechanical Engineering on the Commission. This paper was the first of a series to be given by Mr. Gardner before the branch on the mechanical engineering side of the work of the commission. He discussed especially the legislation providing for safety devices and their development on railway rolling stock for the safety of the employees.

### UNIVERSITY OF MAINE

The first regular meeting of the Student Branch of the University of Maine was held on September 28 at which the following officers were elected: J. M. Dodge, president; L. T. Rowley, vice-president; A. G. Smith, secretary and treasurer; Prof. C. H. Lekberg, honorary chairman, and L. E. Mulloney and G. C. Marble, executive committee.

### UNIVERSITY OF MICHIGAN

The first regular meeting of the University of Michigan Student Branch was held on October 21, at which a special election was held. H. S. Manwaring resigned the secretaryship to become president of the branch. Frank C. Riecks

was elected vice-president and corresponding secretary; Gordon Smith, treasurer, and E. H. Merritt, recording secretary. Plans were discussed relative to the membership campaign and to holding a smoker for the purpose of stimulating interest in the branch. A motion was carried to raise the renewal rate for The Journal for graduates from $2.00 to $2.50 and to use the extra $0.50 toward the support of the branch.

### UNIVERSITY OF MINNESOTA

The second regular meeting of the University of Minnesota Student Branch was held on October 16. Lieut. E. P. Rollman of Battery F, First Field Artillery, M. N. G., spoke on the manufacture and use of shrapnel. After giving briefly the history of the development of this modern shell and describing the styles used by the European nations, he explained with the aid of two section models the construction and firing mechanism of standard United States shells.

### UNIVERSITY OF MISSOURI

A meeting of the University of Missouri Student Branch was held on October 21. Professor W. J. Shephard of the Political Science department of the University of Missouri spoke on City Managership, a New Field for Engineers. In his talk, Professor Shephard said that our city governments and civic affairs were coming to be run as a business proposition, instead of under the corrupt and inefficient political rule of politicians.

The city's business must be organized and managed the same as that of any business firm or corporation. The corporation, which would adopt the practice of having its officers and employees elected, as is the case in the management of most cities, would soon go into bankruptcy on account of the inefficiency resulting. The same is true of the present election system in most cities it results in inefficiency, which in some instances has become so bad as to be brought forcibly to public attention throughout the whole country. The professional element is as necessary in the management of city government as in that of a corporation.

The speaker then showed by the use of a diagram how things are run under the present elective system, and how there is a lack of the responsibility element present of the worst sort. He then explained the new commission form of government for cities, and used as examples several of the cities of this country, which have adopted it, especially Dayton, Ohio. Dayton's system consists, first, of a commission of five men, who are elected by the people. They, in turn, appoint a city manager, in whose hands rests the active management of the city's affairs. It is not necessary for him to be a resident of the city at the time of his appointment; in fact, this is hardly ever the case. In most cases he is an engineer, and has charge of the hiring of the men under him. In other words, he is to the city as the chief engineer of a manufacturing company is to his company. Wherever this system has been tried, it has brought increased efficiency over that of the old system, for the lack of the responsibility element is no longer present, and each employee must be efficient to hold his job.

The speaker then outlined what he considered the three chief characteristics of the city manager, namely: *a* He should be a good all around engineer. Under this head, he mentioned some of the duties, classified under the various branches of engineering, which would fall to the city manager, especially in the small city. Under mechanical and electrical engineering he placed supervision of power and light plants, water works, heating and ventilation for public buildings, etc. Under civil and sanitary engineering he placed care and building of roads and pavements, sewerage systems, etc. *b* He must be a good business man. *c* He must have a thorough knowledge of men, and know how to manage them successfully. He pointed out how this position for the engineer, not only was one of dignity and honor and of good compensation, but it gave him an opportunity for the accomplishment of big things, and also that the number of cities using this form of management was increasing rapidly, thus enlarging this field of engineering activity. So he urged those who were students in mechanical engineering to consider seriously the advantages and opportunities offered in this field.

The following officers were elected for the first semester 1915-16: J. C. Squires, president; Fred P. Hutchison, secretary-treasurer; Ralph Coatsworth, corresponding secretary; Professor J. R. Wharton, Troy Russel and F. Nelson Westcott, Governing Board.

### UNIVERSITY OF NEBRASKA

A meeting of the University of Nebraska Student Branch was held on October 2. Practically the entire evening was devoted to a discussion of several practical problems of interest to the engineer in general. These problems were sent in by outside engineers in practical work. Professor Hoffman announced the problem by sketch and explanation. The discussion was very enthusiastically entered into.

### YALE UNIVERSITY

At a meeting of the Yale University Student Branch held on October 5, the following officers were elected: E. B. Ripley, chairman; W. B. Day, secretary, and W. C. Keeley, treasurer.

# EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

## POSITIONS AVAILABLE

*The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.*

69 Representatives wanted in all the leading cities for a line of vacuum heating specialties. Apply through Society.

108 Large European concern wants superintendent thoroughly posted in the manufacture of rubber shoes, technical and surgical articles, covering for rollers, tubes of all kinds, balls, toys and similar articles made of rubber.

116 Technically educated engineer wanted in the further development of plans for constructing an improved rock-tunneling machine now in operation in New York. Will require engineer having sufficient financial backing to be able to devote part time to this proposition until placed upon self-sustaining basis and before any considerable return can be expected.

136 High grade designers wanted by Pennsylvania concern. Men needed with drawing office experience, particularly on heavy machine tools and similar machinery.

140 Engineer, or designer and draftsman on hydraulic press work. Man experienced in hydraulics, capable of making designs and drawings for special presses as veneer, binder board, hot plate presses, etc. Location, Pennsylvania.

190 Foremen experienced in the manufacture of rubber articles for European concern as listed in position 108.

192 Production engineer or mechanical superintendent for pulp mill; man with technical training and practical experience, familiar with modern methods of machine shop management, etc. Name confidential. Apply by letter.

205 Draftsman experienced in the design of bending rolls and who has had actual work in this line. Location, Southern States.

282 Machinery salesman, preferably one experienced in line of refrigerating machinery. Location, Philadelphia, with occasional trips within one hundred miles.

313 Detail draftsman for chemical work; must have some knowledge of chemistry. Apply by letter. Location, New York.

314 Draftsman for wood factory building; must be familiar with piping and belt drives. Apply by letter. Location, New York.

323 Live company engaged in manufacture of projectiles want high grade engineers for important positions. Prefer men with similar experience. Name confidential.

324 Three or four competent men to act as foremen in manufacturing plant in assembling of mechanical parts of munitions. Salary $100 to $125 a month. Location, New Jersey.

320 Young mechanical engineer with one or two years' experience in shop practice, wanted for drafting and testing work with concern doing general foundry and light machine shop work. Testing work will be mainly on power and heat transmission and the economical operation of mechanical devices in the shops, and for the first few months drafting out the general arrangement of the foundry, shops and apparatus. Give references and salary expected. Location, Middle West.

333 Machinist, pattern maker, draftsman and designer wanted as shop assistant for New Jersey concern. Salary to start, $30.

336 Draftsman with at least five years' experience in machine design, pipe work, etc. Salary, $125 month. Location, New Jersey. In applying state record of positions held and dates.

345 Massachusetts manufacturer of small electrical apparatus in quantities, requires the services of an assistant purchasing engineer for inspection of incoming materials; requires thorough familiarity with insulating and composition casting materials with practical knowledge of metal working and similar machinery. In applying give details covering age, nationality, education, practical experience, salary.

352 Machine shop foreman experienced in the building and manufacture of metal lathes. Salary, $2500 or more, depending on experience and ability to produce results. Location, Middle West.

353 Draftsman and one checker on open hearth, Bessemer and power plant work. In applying give full details of experience, references and salary expected. Location, Chicago.

356 Night superintendent thoroughly experienced in machine shop practice as applied to the manufacture of automobile parts and fairly well versed in the principles of efficiency management. Location, Chicago.

357 Salesman experienced in marketing high grade hot rolled electric and open hearth steel specialties; one having sufficient knowledge and information to post operation in securing proper tonnage for mills. In applying state age, experience and salary expected.

358 Draftsman experienced in design of steel pulleys; must be accurate, rapid and industrious. Salary about $25. State age, experience, previous employers and references. Location, Massachusetts.

362 Recent engineering graduate as research assistant in engineering library. Knowledge German and French essential. Location, New York. Library experience desirable, but not necessary.

365 Foreman for machine shop. Prefer one who has had eight or ten years' experience in gas engines or automobile motors, in modern factories and who is familiar with modern practices, who can get out production and understands thoroughly the handling of modern jigs and equipment. In applying give experience, salary desired to start, and references. Location, Ohio.

366 High grade draftsman competent to take charge of a number of men and do own calculating, with at least ten years' experience in drafting room. Location, Pennsylvania.

369 Plant engineer or millwright as superintendent for a plant employing approximately one thousand men; technically trained man preferred with several years experience in plant maintenance, development of ideas, erection of new buildings, etc. Record must show successful previous connections. Salary proportionate to experience and ability. Location, Middle West.

370 Young graduate engineer as salesman for water purification apparatus, filters and softeners for industrial and municipal supplies in New York and vicinity. Preference given to one who has good working knowledge of inorganic chemistry and with selling experience. In applying give full details of age, education, experience and salary.

372 Young engineer about thirty years of age who has studied efficiency work and with some experience in organizations doing such work. Excellent opportunity for industrious, intelligent and tactful man to get results without affecting present organization and introducing too much "system"; salary, $1500 to $2000 to start. Location, Connecticut.

376 Technical graduate, with one or two years' experience; to act as an assistant in steam engineering and general power work. State qualifications in detail and salary expected. Location, Cleveland, Ohio.

381 Experienced machine tool designer, prefer man with planer experience. In applying furnish records, salary expected and when ready to report for duty. Location, New Jersey.

384 Expert on power plant work and equipment with valuable patents in that line, strong personality, excellent executive and salesman, desires to invest several thousand dollars in established engineering enterprise or form partnership with consulting engineer. Advertiser is also ready to act as consulting engineer to engineering concerns.

385 Draftsman and assistant engineers familiar with mill construction, power plant design and industrial engineering. Apply by letter, stating experience, education, when and where born, nationality of parents, married or single, former employers, salary expected, and when available.

386 Tool designer, accustomed to heavy machine tool work. Location, Illinois.

387 Assistant factory superintendent; technical graduate and man with experience in handling men and in the production of small accurate work. Salary, $2500 to $3000 to start, but dependent largely on ability. Location, Connecticut.

388 Capable tool designer who is resourceful and can follow his own work through to completion. Man with practical shop experience as well as technical education. Location, Connecticut.

390 Designers and detailers for drawing room in Boston doing printing press work. Printing press experience not essential. Applicants must be careful, industrious and have sound mechanical knowledge.

391 Mechanical draftsman with blast furnace and rolling mill experience. Location, Pennsylvania.

394 Superintendent, machine tools, foundry and machine shop, employing 900 men. Prefer good executive to a mechanical expert; must have shown ability in factory management. Salary not limited. Apply by letter. Name confidential.

397 Competent shop superintendent or general machine shop foreman. Salary, $150 to $200 a month, according to ability. Location, Ontario, Canada.

### MEN AVAILABLE

L-347 Member, age 35, technical training in mechanical, electrical and building construction course, Lowell Institute, Boston. Three years experience in drafting room and machine shop on steam pump work; ten years experience in charge of drafting room and design of steam boilers and steel plant work in Massachusetts, desires permanent position with opportunity for advancement with manufacturing concern, large central station power company or consulting engineer. Location preferably Boston.

L-348 Sales engineer with technical education and over five years practical experience (past four years with one concern), would like to communicate with first class manufacturing concern having an opening as manager or assistant. At present employed.

L-349 Technical graduate, age 28, dependable, progressive with thorough, practical shop and engineering department experience, desires position as assistant to superintendent.

L-350 Associate-member, M. E., age 38, expert in interchangeable manufacturing, sheet metal stamping and evolution of shapes; economic production of duplicate parts, light mechanical devices and machinery. National reputation as mechanical expert and consulting engineer, author of numerous standard mechanical text books; developer and perfector of machines and devices for commercial efficiency and success, desires position as production engineer where ability to eliminate costs, operations and intricate mechanisms and effect maximum efficiency and output at minimum cost will earn $4000 per year, and more when results justify increase.

L-351 Ordnance engineer, member, age 32, married, M. E., degree 1913, several years civilian employee of Ordnance Department, U. S. Army, experienced in design of various kinds of ordnance including guns, carriages, ammunition vehicles, ammunition and familiar with the design of machine rifles and their equipment, desires position in connection with the design and manufacture of ordnance.

L-352 Member, with experience in the design of locomotives and cars, and one who has made a study of the organization and handling of men and also expert examination of properties in order to bring them to a high point of efficiency, desires position as manager of large manufacturing concern.

L-353 General manager or superintendent of foundry, has had charge of some of the leading foundries of the country, capable of handling any foundry proposition, desires position.

L-354 Mechanical engineer, Stevens graduate, 1900, twelve years' mechanical superintendent, three years assistant manager, of large manufacturing plant; thoroughly versed in design and construction of mill buildings, installations and economical operation of electrical generators and motors, engines, boilers and manufacturing machinery, desires position. Vicinity of New York preferred.

L-355 Mechanical engineer, broad shop and office experience, expert in the manufacture of shrapnel and all sizes of high explosive shells, desires opening as organizer and manager of concern taking up shell work, or allied parts.

L-356 Mechanical engineer, age 33, married, graduate in mechanical engineering, eleven years' experience, four years as mechanical engineer in charge of design and construction of various machinery, has had experience in machine shop, inspection and testing, desires position as mechanical engineer, superintendent, chief draftsman or other executive position.

L-357 Junior, age 30, married, M. E. graduate, six years' designing experience in automobiles, motor trucks, production tools, small punch and die work, a large variety of special and semi-automatic machinery and inspection gages; possessed of sound originality and knowledge of tool room practice, careful and systematic, desires position in efficiency or production department.

L-358 Junior member, technical graduate, wishes connection with manufacturing firm which is about to make extensive addition to its plant as a representative of the owner to supervise the work and layout of the contractor, engagement to terminate when contract is finished to the satisfaction of the owner.

L-359 Practical and educated man of broad experience in manufacturing duplicate parts on the interchangeable basis, would like to hear from reliable firms with a view to securing the services of a live up-to-date executive, especially trained in the handling of difficult problems on all kinds of automatic machines and the die-casting of duplicate parts.

L-360 Technical graduate, wide experience as railway mechanical engineer, machinist, motive power draftsman and mechanical engineer, desires position along these lines, or one as mechanical inspector, assistant superintendent motive power, or assistant to general manager. Location, immaterial.

L-361 Technical graduate, age 31, nine years' broad experience in designing, manufacturing and testing special machinery, also delicate instrument work, thoroughly familiar with drawing office methods, pattern, foundry and machine shop practice, good executive, can handle correspondence, and draw up specifications, desires position. Location, immaterial.

L-362 Member, specializing in the installation of scientific management, seeks engagements in that line. Speaks Spanish fluently and would accept engagements in Latin America for the investigation of the efficiency and possibilities of improvement of enterprises, or would do betterment work.

L-363 M. E. graduate, two years general work and three and one half years' experience handling men, at present department foreman in large ammunition plant, desires responsible position with manufacturer of metal products.

L-364 Two young engineers, graduates M. E. and E. E., four years' sales and management experience, are open for attractive sales or manufacturing proposition. Want territorial agency, preferably New England for live-wire commodity. Extensive acquaintance among manufacturers. Capital investment possible.

L-365 Member, age 37, manufacturing plant construction and operating experience, also purchasing and structural steel estimating, two years as mechanical engineer with packing house, now engineer and traveling superintendent for a group of cotton oil mills. Salary $3600. No traveling.

L-366 Junior member, seven years' experience in design of oil engines, jigs, tools, power plant details, and as executive in charge of a small food project, desires connection with engineering or manufacturing concern.

L-367 Associate-member, graduate engineer, broad selling experience in steam specialty line, covering territorial representation, special representation in building up agent's territories, sales management, sales distribution and advertising, also some experience in manufacturing, desires position with concern in need of such a man to grow up with the business.

L-368 Member, technical graduate, ten years' experience in general engineering work with prominent consulting engineers, accustomed to responsibility and control, familiar with inspection and tests of materials and power equipment, fuel combustion, power production, plans and specifications, twelve years' experience in machine shop work, desires executive position with responsible firm or consulting engineer.

L-369 Works manager, age 40, with large and long established company manufacturing power equipment, twenty-two years general shop experience, having handled men for fifteen years, experienced in large production, having supervised from fifteen hundred to eighteen hundred men, desires to make a change.

L-370 Student member, M.E. graduate, Columbia 1915, with shop drafting room and power plant experience, employed at present, but desires to connect with an engineering or manufacturing concern in or about New York, with whom there is a chance for advancement.

L-371 Gas engine detailer, graduate mechanical engineer, 1911, age 26, shop experience erecting and testing engines and tractors, operating in field, detailing, wants further experimental drafting. Location, Middle West.

L-372 Member, South American, reliable, capable sales engineer, five years with present connection prominent Eastern jobbing house, sales, conversant with Spanish language

and understands the Latin people, have had considerable business experience and can efficiently represent manufacturers, hardware, mill and railroad supplies, agricultural or machinery lines, desires correspondence from concerns interested in developing South American business. Can furnish unquestionable references.

L-373 Member, graduate M.I.T., age 32, with special experience in power station work, heating and ventilating systems and electrical work, both in design and installation, desires position as mechanical engineer or superintendent of construction.

L-374 Mechanical engineer, graduate Columbia 1912, experienced in design and construction work, desires permanent position, preferably in sales or where there is a chance to work into sales or commercial end of business. Location, immaterial. Salary, $1500.

L-375 Junior member, mechanical graduate 1913, one year shop work, eighteen months drafting and designing, four months in responsible charge of laying water mains, desires position with construction contractor. Available in December.

L-376 Manufacturer's agent, experienced and competent, invites correspondence and investigation by those who desire a live representation in Chicago district.

L-377 Graduate mechanical engineer, twenty years' active experience, rising from shop and drafting room to chief engineer in charge of design, construction, maintenance and operation of large industry; long experience in steel works, also in heavy and medium heavy machinery design and operation, purchasing and inspection. Aggressive executive, thorough, economical and particularly successful in overcoming troubles and improving operating conditions as well as working out original problems of design and carrying through to a finish a complete enterprise, desires to change after long service in present position. Terms moderate.

L-378 Member, technical graduate, age 37, married, eleven years' practical experience in U. S. and abroad in general power station design, engineering and construction, also five years' experience in engineering, administrative and sales department of manufacturing corporations, desires to make connection with manufacturing company as purchasing engineer or executive position. Would eventually be able to invest some capital in right proposition. Has thorough knowledge of German, working knowledge of French. At present employed. Location preferred on Pacific Coast.

L-379 Associate member, Lehigh University graduate in mechanical engineering, with eighteen years' varied experience in mechanical, electrical and civil engineering lines, involving design, supervision and direct charge of construction work, plant operation, purchasing, reports, etc., all in connection with electric railways, lighting plants, power and industrial plants, wishes an executive position as manager, superintendent, or sales engineer, with larger field and responsibility. At present employed. Southern location preferred.

L-380 Junior member, age 26, technical graduate 1912, two years in testing department of large eastern electrical manufacturer, and experience with contracting concern, desires position with company operating power plants and street railways in middle west. Salary, $1200. At present employed.

L-381 Member, experienced in the manufacture of guns, small tools and machinery desires change. Highly successful as an executive in getting quality goods at low cost. Now superintendent of factory building high grade machinery.

L-382 Man of wide practical experience in inventing, designing and constructing special machinery would like a position along these lines. Salary, $3000.

L-383 Member experienced in power plant and shop work, responsible charge of estimating, production and costs in large concerns, some teaching experience; five years active participation in welfare and social work in industrial plants.

## ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accesions to the libraries of the A.I.E.E. and A.I.M.E. can be secured upon request from Calvin W. Rice, Secretary of Am. Soc. M. E.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Report of of the Committee to formulate standard specifications for the construction of steam boilers and other pressure vessels and for their care in service known as the Boiler Code Committee. Rules for the Construction of Stationary Boilers and for allowable working pressures. ed. 1914. *New York, 1915.* Gift of A. M. S. M. E.

——— Condensed catalogue of mechanical equipment, 1915. *New York, 1915.* Gift of A. S. M. E.

BALL BEARINGS, B. D. Gray and H. Wickland. Presented by B. D. Gray, April 14, 1915, before Electric Vehicle Association of America, at Philadelphia. Gift of Hess Bright Mfg. Co.

CARNEGIE ENDOWMENT FOR INTERNATIONAL PEACE. Growth of Internationalism in Japan. Publication no. 6. *Washington, 1915.* Gift of Carnegie Endowment for International Peace.

CONVERSION CHART. Merl R. Wolfard and C. K. Carpenter, *New York, J. Wiley & Sons, 1915.* Gift of publishers. Price $ .25 net.

A chart 12x34 on logarithmic co-ordinate paper. By means of this chart, conversions between units of work, pressure, time or temperature, as well as surface, area, weight or mass conversions for all common units, including metric, may be quickly made. W. P. C.

COOLING PONDS FOR CONDENSING ENGINES, L. H. Parker. *Boston, 1915.* Gift of Spray Engineering Company.

ELEMENTARY LESSONS IN ELECTRICITY AND MAGNETISM, S. P. Thompson, ed. 7, *New York, 1915.* Gift of Macmillan Company.

Profesor Thompson has completely revised the book for this edition. There is a new chapter on Wireless Telegraphy, and another on the modern conception of the Electron. W. P. C.

THE EVILS OF GOVERNMENT OWNERSHIP, J. Bourne, Jr. Gift of American Electric Railway Association.

HIGH EXPLOSIVE SHELLS. A reprint of important articles presented in the American Machinist, from June to October, 1915. Gift of American Machinist.

HYDRO-ELECTRIC DEVELOPMENT OF THE COHOES COMPANY, Cohoes, N. Y. Reprinted from General Electric Review. Gift of Sanderson & Porter.

INTERNATIONAL IRRIGATION CONGRESS. Official proceedings of the 21st, 1914. *Ottawa, 1915.* Gift of Canada. Department of the Interior-Irrigation Branch.

MACHINE DESIGN, A. W. Smith and G. H. Marx. ed. 4. *New York, J. Wiley & Sons, 1915.* Gift of publishers. Price $3.00 net.

The text has been thoroughly revised in this edition, and the results of new investigations of machine elements have been included. W. P. C.

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION. Proceedings of Annual Convention, 11th-13th. *New York, 1912-14.*

——— PROCEEDINGS OF SEMI-ANNUAL CONVENTION, 1912-15. *1912-15.* Gift of National Machine Tool Builders' Association.

NEW ORLEANS. SEWERAGE AND WATER BOARD. Hurricane of Sept. 29, 1915, and subsequent heavy rainfalls. Gift of Sewerage and Water Board of New Orleans.

ÖSTERREICHISCHER INGENIEUR UND ARCHITEKTENVEREIN. Jahrbuch 1915. *Wein, 1915.* Gift of Österreichischer Ingenieur und Architektenverein.

PRACTICAL SURVEYING, for surveyors' assistants, vocational and high schools, Ernest McCullough. *New York, Van Nostrand Co., 1915.* Gift of publishers. Price $2.00.

A simply worded text book, presupposing only a knowledge of arithmetic. W. P. C.

PRESS REFERENCE LIBRARY. (Western Edition.) Notables of the West. vol. II. *New York-Los Angeles, 1915.* Gift of F. R. Freeman.

SCHWEIZERISCHER INGENIEUR UND ARCHITEKTEN VEREIN. Geschäftsbericht für die Berichtsperiode von Ende Juli 1913 bis Ende Juni 1915. *Zurich, 1915.* Gift of Schweizerischer Ingenieur und Architekten Verein.

THROOP COLLEGE. Inherent Voltage Relations in Y and Delta Connections. Bulletin vol. 23, no. 64, July 1914.

——— President's Sixth Annual Report. Bulletin vol. 24, no. 68, July, 1915. *Pasadena, 1914-15.* Gift of Throop College.

U. S. Dept. of Agriculture. Yearbook, 1914. *Washington, 1915.* Gift of C. W. Rice.

The Valley Pipe Line Company's Oil Pipe Line. Coalinga Oilfields to Martinez, California. Reprint from Journal of Electricity, Power and Gass, Sept. 4, 1915. Gift of Sanderson & Porter.

### EXCHANGES

American Society of Civil Engineers. Transactions vol. LXXVIII. *New York, 1915.*

Institution of Civil Engineers of Ireland. Transactions vol. XLI. *Dublin, 1915.*

Purdue Engineering Review, vol. XIII, 1913. *Lafayette, 1913.*

U. S. Patent Office. Annual report of the Commissioner, 1914. *Washington, 1915.*

### TRADE CATALOGUES

Daimler-Motoren Gesellschaft. *Stuttgart, Germany.* Mercedes Cars.

Edge Moor Iron Co. *Edge Moor, Del.* General Catalogue no. 52. Water Tube Boiler. *1915.*

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *Oct., 1915.*

Goldschmidt Thermit Co. *New York City.* Reactions. vol. 8, no. 3. *1915.*

Ingersoll-Rand Co. *New York, N. Y.* Catalog no. 76. Water lifted by compressed air. Calyx core drills. *July, 1915.*

Leschen, A. & Sons Rope Co. *St. Louis, Mo.* Leschen's Hercules. *Oct. 1915.*

McNab & Harlin Manufacturing Co. *Paterson, N. J.* Monthly Herald. *Oct. 1915.*

Rice, Cyrus W. *Philadelphia, Pa.* Catalogue describing the Cyrus W. Rice Intermitting Circulating-Aerating-System for the Mechanical and Chemical Clarification and Purification of Water and Sewage Without Filtration.

Underfeed Stoker Co. of America. *Chicago, Ill.* Publicity Magazine. *Nov. 1915.*

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. *Nov. 1915.*

Williams Patent Crusher & Pulverizer Co. *St. Louis, Mo.* Bulletin 107. Durability of Williams Crushers and Pulverizers.

——— 112. Conglomerate ore.

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American Sewerage Practice. Vol. II—Construction of Sewers, Leonard Metcalf and H. P. Eddy. *New York, 1915.*

Analysis of Non-ferrous Alloys, Fred Ibbotson and Leslie Aitchison. *London, 1915.*

Berichte der Schweizerischen Studienkommission für elektrischen Bahnbetrieb, Dr. Wyssling. Heft. I. *Zürich, 1908.*

Bibliography of Colorado Geology and Mining from the earliest explorations to 1912. Colorado Geological Survey. Bulletin no. 7. *Denver, 1914.* Gift of Survey.

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## THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal.

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*Boston:* H. N. Dawes
*Buffalo:* David Bell
*Chicago:* H. M. Montgomery
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